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MEMOIRS
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VOLUME 91

THE GEOLOGY AND COAL RESOURCES OF THE BOKARO COALFIELD

By

A. B. DUTT, D. SC., F. G. S., F. N. I.,
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PREFACE

The Bokaro coalfield, lying to the west of the Raniganj and Jharia coalfields, in the Damodar Valley of Bihar, has been third on the list of Indian coalfields, so far as production is concerned. It has a total area of 200 sq. miles (approximately) and has been noted for some of its thick coal seams, out of which two have attained a thickness of about 100 ft. each and one of them possesses coals of the metallurgical grade.

This coalfield, after it had been geologically surveyed by Mr. T. W. H. Hughes in 1866-67, had not been entirely re-surveyed systematically, although a number of geologists, both official and private, had carried out detailed prospecting in a number of its sectors. Amongst them, mention may be made of Messrs. T. H. Ward, C. J. E. David, R. W. Church, G. C. Lathbury, L. L. Fermor, E. H. Roberton and W. Chowdhury.

In view of the importance attained by the Bokaro coalfield in the emergency created by World War II, a geological re-survey of the area was begun by the author in February, 1944, and carried on with occasional interruptions, up to the year 1951. Detailed mapping of the whole coalfield on the scale of 4 inches to 1 mile, followed up by drilling in critical sectors, was carried out during this period.

It is quite obvious that without the information collected from colliery and borehole records, it would have been almost impossible to locate the coal seams and their associated intrusions over a considerable portion of the cultivated ground. For effective correlation of the coal seams, all the existing collieries were visited, and the available information collected. Analyses of the coal samples were carried out in the initial stages by the late Shri J. C. Gupta, the then Chemist of the Dhori Colliery Laboratory.

The author is grateful to Dr. E. R. Gee, late Superintending Geologist, Geological Survey of India, for having given him valuable suggestions and advice during the course of the Survey, which was completed in 1951.

The re-survey of the Bokaro coalfield was completed in 1951.

CALCUTTA;
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A. B. DUTT

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SUMMARY

The present work on the Bokaro coalfield has mainly an economic aspect with special reference to an accurate assessment of the reserves of different grades of coal contained therein.

In the Bokaro coalfield, the geological formations met with are as follows :—

(3) Post-Gondwana Intrusive Igneous rocks.

(2) Lower Gondwanas
- Panchet Series
  - Upper Panchets
  - Lower Panchets
- Damuda Series
  - Upper
    - Raniganj stage or Upper Coal Measures
    - Barren Measures containing Ironstone Shales facies
  - Lower
    - Barakar stage or Lower Coal Measures
    - Talchir stage

(1) Archaean rocks.

In addition to co-ordinating the information collected by the previous workers from different parts of the coalfield, the present work has, for the first time, elucidated certain lithological, structural and economic aspects of the coalfield, which are detailed below :—

1. The Barren Measures stage of the Damuda Series is being described from the Bokaro coalfield for the first time. In West Bokaro, the stage equivalent to the Barren Measures in part, was mapped in the early stage as Ironstone Shales. Detailed strike-mapping by the author has revealed the existence of a number of ironstone shale horizons, separated by massive sandstones and micaceous-carbonaceous sandy shales. This whole succession corresponds broadly with the type Barren Measures of the Jharia coalfield and has been termed as such.

2. The petrography of the intrusives of the Bokaro coalfield is described. The lamprophyres of this coalfield are olivine and leucite bearing minette and kersantite and appear to belong to the same stock as those described from the adjoining Jharia and Raniganj coalfields. From structural considerations it is proved that the doleritic intrusives of the Bokaro coalfield are later than the lamprophyre intrusions.

3. The detailed mapping has revealed the existence of different types of faults, *e.g.*, normal, step, trough, scissors, etc. Most of the important faults, including the boundary faults, trend east-west, though a number of cross and oblique faults are also found. Of the faults, the more important ones are the Gobindpur-Pichhri, Dhori-Pichhri, Borea and Kathhara faults in East Bokaro and Banji and Duni faults in West Bokaro. All of them are normal faults. The post-Gondwana faulting movements are inferred to be broadly synchronous in age with the lamprophyric intrusions.

4. The predominance of normal faulting, coupled with the absence of any significant folding of the rocks indicates that like the easternmost Raniganj coalfield the active forces in the deformation of this basin were tensional in nature (*vide*, E. R. Gee, 1932, p. 106). This is in sharp contrast to the style of deformation in the centrally placed Jharia coalfield where the major structural complications are thought to have been caused by tangential compression (*vide*, C. S. Fox, 1930, p. 154).

5. Damages caused to the coal seams by numerous dolerite and lamprophyre intrusions, as well as by the faulting movements, have been assessed in detail. It has

been found that while the effects of the doleritic intrusion are not usually perceptible the lamprophyre intrusions have affected the coal by metamorphism and metasomatism to about double the thickness of the intrusive bodies, natural coke, sometimes with columnar structure, having been formed on both the sides.

6. Most of the normal faults have adversely affected the coal seams of the area. Besides breaking the continuity of the coal seams, they have increased in varying degrees the dip of the seams, and have added to the difficulties of mining.

A notable exception is, however, recorded in the Kargali seam of the Kathhara area, where a normal fault has affected a relative upward displacement of the seams.

7. The different coal seams in East Bokaro, *e.g.*, Kargali, Bermo, Karo seams, etc., are described in detail and correlated, for the first time, all over the stretch of Barakar Measures on physico-chemical basis.

8. Systematic analysis of the coal seams of the East Bokaro field has revealed the existence of high reserves of coking coal. The author is of the opinion that after the coking coal reserves of the Jharia coalfield are depleted to a considerable extent India will have to depend largely on the Bokaro coalfield for her requirements of metallurgical coal.

9. Huge reserves of good quality coking coal have been proved in the West Bokaro coalfield by detailed large-scale mapping and drilling. The total reserves, qualitywise, could not be given as all the coals have not been graded. The reserves of coal in each seam, however, are given in the text while dealing with the coal seams.

10. Continuation of the Kargali seam to the south of the Gobindpur-Pichhri fault in the Dhori colliery area has been established during the course of this work, with the possibility of subsequent mining activities in that area.

11. Continuation of the thick Kargali seam in the Jaridih area (south of Bokaro Colliery) has been predicted by the author on structural considerations.

12. Tabular description of the different coal seams cyclothems, along with their proximate analyses, has been given. It is noticed that the ferruginous component in the Barakar cyclothems is more abundant in the West Bokaro area, possibly reflecting the advent of semi-arid conditions in the western provenance.

13. Detailed recommendations for improving the quality of the Kuju seam, *e.g.*, by blending, washing, etc., have been given.

14. Several thin coal seams have been located in the Raniganj Measures during the course of this work. The coal seams are interbedded with shales and are of not much economic importance.

15. Deposits of minor economic significance, available in the Bokaro coalfield *e.g.*, fire-clay, iron ore, etc., have been described. The fire-clay deposits, underlying the top Karo Seam with an average thickness of six feet are found to be well suited for the manufacture of fire bricks.

In addition to discovering the above mentioned features of the Bokaro coalfield, the author's work has been of material help to a systematic development of this basin. A few of the salient points are listed below :—

(i) Based on the author's discovery of huge reserves of coal in the West Bokaro coalfield, the first coal washing plant of India was established in that area in 1951 (started functioning from 26-2-51) with a capacity of 135 tons/hour.

(ii) The existence of the Kargali seam in the Kathhara area was proved for the first time by the author. Large reserves of coking coal have also been proved by the author, and it is due to this work that the area is having the present brisk mining activity in the public sector.

(iii) The opening of the Pipradih Colliery is the direct result of the work by the author.

In addition to fulfilling the economic commitments, the present survey, has brought certain peculiarities of the Damodar Valley coal basins into notice. As one proceeds from east to west, one meets the following coal basins in succession : Raniganj, Jharia, Bokaro, and Karanpura. A comparative study of the three easterly basins indicates :—

(i) An overall increase in the carbon ratio of the Barakar stage towards the centrally located Jharia coalfield ;

(ii) The abundance of carbonaceous matter in the Barren Measures shows an overall increase towards east ; and

(iii) Coal seams of the Raniganj stage dwindle towards west and in the Bokaro coalfield, they are insignificant.

In the opinion of the author, this overall variation in the abundance of carbonaceous matter from west to east as one goes up the stratigraphic column, may possibly reflect progressive eastward migration of the woodlands during the period.

The various points noted above have materially advanced the knowledge of the geology of the Bokaro coalfield, and have helped to get a more coherent picture of the stratigraphy and sedimentation of the Damodar Valley coal basins of India.

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THE GEOLOGY AND COAL RESOURCES OF THE BOKARO COALFIELD

By

A. B. Dutt, D. Sc., F. G. S., F. N. I., *Superintending Geologist* (Retd.), *Geological Survey of India.*

Part I

CHAPTER I

INTRODUCTION

The Bokaro coalfield, the eastern end of which lies within a couple of miles of the outcrop of Talchir extending westwards from the Chandrapura Section of the Jharia coalfield and the western end about a mile from the eastern edge of the North Karanpura coalfield has been third on the list of Indian coalfields so far as production is concerned. It has been noted for its containing some thick coal seams, out of which one has attained a thickness of over 100 feet and for its containing coals with coking properties so as to make them suitable for use in metallurgical purposes.

Acting on the recommendations of the Coal Committee in their report for 1845 (published in 1846) for the geological investigations of the coal formations of India Mr. D. H. Williams, who had been working in the Geological Survey of Great Britain and had been engaged in the examination of the South Wales Coalfield, was appointed Geological Surveyor to the East India Company. He was first deputed to investigate the Raniganj coalfield, the examination of which was completed in 1847.

Mr. D. H. Williams 1847-48

Later he investigated the Bokaro coalfield for the first time ; this field was named by him after the Bokaro river which traverses a distance of nearly 30 miles in the coalfield. The river is of great importance in so far as the drainage of the area is concerned. Due to his sudden death in November, 1848, in consequence of an attack of jungle fever, his report on the Bokaro coalfield could not be completed ; only rough drafts on the report, to be subsequently developed into a comprehensive report found among the papers of the late Mr. Williams, have been published (Williams, 1852). Mr. T. W. H. Hughes next examined this coafield in 1866 and he was in favour of giving the name of

the lofty Lugu Hill (△ 3200) to indicate the field. He writes (Hughes, 1867, p. 39), "Standing, as the hill does, in the middle of a plain, and rearing its summit far above any other eminence in the neighbourhood, it is the most prominent natural object which meets the eye for miles around, and could never fail to attract attention to itself".

T. W. H. Hughes, 1866

The Lugu hill, situated in the middle of a plain, divides the coalfield for all practical purposes into two separate ones.—the East Bokaro and West Bokaro coalfields—according to their positions with reference to the hill.

Anderson, Wright & Co.

Some time elapsed before Messrs. Anderson, Wright & Co., of Calcutta took up the prospecting licence of the entire coalfield from the Rajah of Ramgarh (Padma), commenced extensive explorations in 1907 and fioated the company—Bokaro & Ramgur, Ltd.

T. H. Ward

Prospecting operations were taken up jointly by the Bokaro & Ramgur, Ltd. and the East Indian and Bengal Nagpur Railways. A prominent fault, the Gobindpur fault, aligned roughly in a N. W.—S. E. direction in the western portion of East Bokaro and then running almost W.-E. in the eastern end of the field, divides the area into two sections. The section east of the fault, which may be called the Kargali section after the village of this name, was reported on by Mr. T. H. Ward, in 1908. As a result of the work two blocks of 3,750 bighas (1 acre-3½ bighas) each were demarcated :— (1) the Joint E. I. & B. N. Railways' block later worked as the Bokaro Joint Colliery, and (2) the G. I. P. Railway block afterwards opened up under the name of Kargali colliery. The seam worked in both the areas was Ward's Kargali seam, 70 to 100 ft. in thickness. To the contiguous east of the Kargali colliery the Company took up an equal area and opened up the Dhori Colliery.

C. J. E. David

The section of the field lying to the west of the Gobindpur fault up to the Lugu Hill and known as the Gumiya section, was investigated in 1909 by Mr. C. J. E. David who found only one coal seam, D, worth exploitation. He tried to sink a prospecting shaft right through the seam, but was unsuccessful due to rush of water. He had to rely on the results of analysis of samples obtained from cores of a diamond drill hole and this made him condemn the seam. Later in 1911 he revised his opinion and reported that the D seam contained fairly first class coal. Two blocks were thereafter demarcated—(1) the Jarangdih block for the Bombay, Baroda and Central India and the Madras and Southern Mahratta Railways, worked as the Jarangdih Colliery and (2) the Sawang block for the East Indian and Bengal Nagpur Railways jointly worked as the Sawang Colliery. In these two cases also the operations were at first confined to the Kargali seam. In the Jarangdih Colliery, however, a disastrous fire-damp explosion occurred on the 7th August, 1930. The pit was allowed to fill up with water to a height of 350 ft. It was de-watered and work was started again by the middle of 1931. Steam driven indestructible Walker fan (capacity : H 500,000 c.ft./minute) was installed. The work continued in the pit till the middle of 1936,

when it was finally closed. Subsequently, however, a younger seam the Jarangdih seam, has been worked in the Jarangdih area.

R. W. Church & C. J. E. David

The West Bokaro coalfield was investigated by Messrs. R. W. Church and C. J. E. David and reported upon by Mr. Church. This portion of the coalfield was divided by him into seven sections, out of which, section 3 proved to be the most important. According to Mr. Church, this portion did not contain any first class coal. As a result of further work, however, Mr. Church revised his opinion and came to the conclusion that seam Nos. 4, 7 and 8 in this section contained workable first class coal and that some second class coals could be changed, by picking, to first class coal. As a result of this he recommended that this section should be blocked out in accordance with the agreement between the East Indian and Bengal Nagpur Railways and the Bokaro & Ramgur, Ltd. Mr. G. C. Lathbury was thereupon deputed by the Agent, East Indian Railway to test the quality of and evaluate the seams 3, 4, 7 and 8 in section 3. As a result of his investigation Mr. Lathbury concluded that there was nothing of any value in the seams under examination either for the railways or from a commercial point of view.

G. C. Lathbury

The Bokaro coalfield, after it had been geologically surveyed by Mr. Hughes in 1866-67, had not been entirely re-surveyed since, although it was carefully prospected by the geologists of Bokaro and Ramgur, Ltd., and by the geologists and mining engineers of the different railway companies. In 1916-17, Dr. L. L. (later Sir Lewis) Fermor investigated in great detail, by mapping (on a scale of 16 inches to the mile) and also putting down boreholes and sampling coal seams, most of the Gumiya section west of the Konar river up to Gumiya and a considerable portion of West Bokaro around Kedla and Jharna. Unfortunately Dr. Fermor's mapping had to be stopped on the completion of his examination of the coal measures due to other important work elsewhere. The sampling and diamond-drilling, however, continued until the programme of work was completed. The results of Dr. Fermor's investigations given in an Interim Report (1917) are published as Appendix I at the end of this Memoir.

L. L. Fermor, 1916-17

Later about 1925, the West Bokaro coalfield was carefully investigated by borings on behalf of Bokaro & Ramgur, Ltd., by Dr. W. Chowdhury and afterwards by Mr. E. H. Roberton. Between these detailed examinations, the East India and Bengal Nagpur Railways had jointly taken lease of an area of 7,600 bighas (less than four square miles) near Kedla and Loiyo.

W. Chowdhury

E. H. Roberton

Due to a difference of opinion between Messrs. Anderson, Wright & Co., and Messrs. Tata Iron & Steel Co., Ltd. over the structures of a coal property in West Bokaro, which the latter was going to take up, the Geological Survey of India was approached to examine the area in question and give its opinion about the reserves of coal in the same. The author was deputed by Dr. C. S. (later Sir Cyril) Fox, the then Director, G. S. I. to examine the area. The work was completed in about two months' time from April 1942. After this, the author was

required by the first-named company to investigate in detail with borings, certain other areas also in West Bokaro coalfield ; this work was finished by the middle of October in the same year.

On account of the growing importance of the Bokaro coalfield in the emergency created by World War II, combined with the intention of Messrs. Anderson, Wright & Co. to develop the area, it was decided by the Director, G. S. I. that in order to arrive at a reliable estimate of the coal reserves of the coalfield and to understand its detailed structure, large scale accurate geological maps prepared by re-survey, as in the case of Raniganj and Jharia coalfields, were indispensable. Accordingly, the present geological re-survey of the Bokaro coalfield was commenced by the author from the middle of February 1944 in the 1943-44 field season and continued through the 1944-45, 1945-46, 1947-48 and 1950-51 field seasons. As new topographical maps, on a scale of four inches to one mile, similar to those prepared by the Survey of India for the Raniganj and Jharia coalfields, were not available in the beginning, the re-survey was started using maps enlarged photographically at the Geological Survey office to four inches to the mile scale from the one inch maps. During the course of the survey it was felt that accurate 4″= 1mile topographical maps were absolutely necessary for the work. Accordingly at the request of the Director, G. S. I. new aerial maps (Scale 4″= 1mile) had been prepared by the Survey of India and the details of the present work were transferred on to the recently constructed maps. The new aerial maps cover the whole of the Bokaro coalfield in fourteen sheets in two series—northern and southern—of Nos. 1 to 7 and 8 to 14 from west to east. The four inches to the mile topographical maps prepared for this re-survey were found to be accurate and presented a reliable basis for detailed geological mapping.

Geological re-survey, 1944-1951

The present geological re-survey of the Bokaro coalfield has been mainly an economic one, attempting at a detailed description and correlation of the coal seams, the geological structure of the coal measures and assessing the damages caused to the coal seams by the numerous intrusions into them. All these investigations lead up to the main question of the total reserve of the different grades of coal in this field. In 1949, at the request to the Conservation of Metallurgical Coal Committee set up by the Government of India, estimates of the reserves of coking coal in the Bokaro coalfield were prepared by the Geological Survey of India. The estimates were compiled from the results of the field work and at the same time the manuscripts for this memoir had been written. In doing this the author had referred to the previous reports as also to the Raniganj and Jharia coalfield memoirs. He had also tried to put together all the data obtainable from colliery offices, official files and from the files of Messrs. Anderson, Wright & Co. While preparing the estimates it became evident that the coking coal reserves of India are inadequate for smelting all the iron ores of this country ; and also that after the coking coal reserves of Jharia coalfield, which is the main store-house of coking coal suitable for metallurgical purposes, have been depleted to an alarming extent, India will have to depend largely on the Bokaro coalfield for her requirements of metallurgical coal.

Present Memoir

Due to pressure of other official duties the author was unable to make a thorough search for plant fossils which are common in the shales associated with the coal seams. Whatever fossils were readily available had been collected during the course of examination of the field.

Acknowledgments

It is quite obvious that without the information collected from colliery and borehole records, it would have been almost impossible to locate the coal seams and their associated intrusions over a considerable portion of the field. All the collieries were visited and the available information collected. The author wishes to express his gratitude to all those who have supplied him with the available information. His grateful thanks are due to Messrs. Anderson, Wright & Co., particularly to Mr. J. P. Evans, for giving the author every facility in the furtherance of his work, and for placing at his disposal all the relevant previous reports and borehole records. He is also thankful to the Company for having the coal samples analysed in the initial stages of the survey at their Dhori Colliery Laboratory by their Chemist, the late Mr. J. C. Gupta. He wishes to place on record his appreciation to the Directors for their permission to incorporate in this memoir the details of a number of boreholes and sections of seams together with their analyses. He is indebted for the assistance and in many cases for the hospitality, to Messrs. S. K. Ghosh, M. G. Fell, W. S. Willis, the late Mr. J. C. Gupta and Dr. J. R. Dinsdale. He is also thankful to Dr. W. D. West and Dr. E. R. Gee, at different times Superintending Geologists of the Circle to which he belonged while carrying out the survey, for paying him visits in the field and for having useful discussions with them. He is particularly grateful to Dr. Gee for giving him valuable suggestions and advice in connection with the survey.

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CHAPTER II

PHYSICAL CONSIDERATIONS

The Bokaro coalfield is situated in the valley of the Damodar river, mostly on the northern or left bank, in the Hazaribagh district, Bihar.

Location

It is the third in the chain of coalfields in the Damodar Valley from east to west, the other two being the Raniganj and the Jharia coalfields. The Bokaro and the Konar rivers respectively traverse the western and central portions of the coalfield.

Limits of the coalfield

The Bokaro coalfield lies between Lat. 23°44′ & 23°49′ and Long. 85°45′ & 86°04½′ in the eastern portion and between Lat. 23°44′ & 23° 50½′ and Long. 85°25′ and 85°45′ in the western portion of the field. The coalfield is entirely surrounded and underlain by the crystalline gneisses, in which are found outliers of the younger rocks in the northern portion of the East Bokaro coalfield. The southern boundary is more regular and runs in a general east-west direction. The eastern and western ends of the field, however, are truncated against the metamorphic rocks.

Area of the coalfield

The Bokaro coalfield is about 40 miles long stretching east to west, in the Damodar Valley and has attained a maximum width of nearly seven miles from north to south near Kuju in longitude 85°30′. The total area is of the order of 200 square miles. The East Bokaro up to the Lugu hill includes about 95 square miles whilst the West Bokaro field 85 square miles. The Lugu area consisting of unproductive rocks at the surface, comprises the remaining 20 square miles.

General Topography

But for the stupendous hill mass of the Lugu hill rising abruptly more than 2,000 feet above the level of the surrounding country, the entire area presents a more or less dissected gently undulating basin with a pronounced southerly slope. This hill, composed of the unproductive Panchet formations, straddling across the middle of the basin, has divided the Bokaro coalfield into its two well known subdivisions ; the East Bokaro and the West Bokaro coalfields.

The major portion of the East Bokaro field, however, extends beyond the confluence of the Bokaro and the Damodar and stretches eastwards along the latter for about 10 miles. The ground level in this area varies between 700 and 900 feet above the sea level and invariably shows a marked rise towards the north and south at the approach of the Archaean-Gondwana junctions—thus attracting all the surface water of the hilly areas of the north and south into the Damodar river, the sacred river of the Santhals. The area is also dotted with innumerable small tanks and *bundhs* which constitute more or less perennial sources of water for the villages situated at a distance from the rivers.

The West Bokaro field is marked by a more uneven and rugged topography. The central axis of this area, marked by a series of small knolls and mounds, forms the watershed between the Bokaro and its principal tributaries. The area is thus highly dissected and presents a tangled wilderness of a network of shallow *nalas* and moderately deep gorges.

The Bokaro along with its innumerable tributaries provides the main drainage of the area. The river enters the area at its north-western corner and absorbs the Dudhia *nadi* from the hilly west about two miles north of Mandu (23°47 ½′ : 85°25′). At the end of a south-easterly run across the western portion of the area for about seven miles, it is joined by the Chotha *nadi* from the south-west and then the Bokaro follows an easterly course for another seven miles till it is met by another important tributary, the Chulia *nadi* from west-north-west. From the confluence wih the Chulia *nadi* the river takes a sharp north-easterly turn and flanking the Lugu hill by the north flows east-south-easterly into the Konar river which enters the field about one mile north-east of Gumia railway station (23°48′ : 85°50′). The Konar river in its turn flows into the Damodar river, about six furlongs south-west of Jarangdih railway station (23°46′ : 85°56′).

Rivers

The Damodar meanders by the south of the East Bokaro coalfield and in spite of frequent incursions into the area the river practically forms its southern boundary.

The high ground extending westwards from Jarangdih to the Lugu Hill forms the watershed between the Damodar and the Bokaro rivers in the western parts of the East Bokaro field while further east the Siladhar hill (△1,086) together with the small hills to the north of the Phusro railway station lies within the eastern part of the coalfield itself. Between the East and the West Bokaro coalfields, abutting against the Archaeans in the south, is the prominent Lugu hill (△3,200). In the West Bokaro area, although not exactly enclosed in coalfield, the Jhuma Pahar (·3061) with the surrounding hills composed of the Archaeans is situated north of the Lugu hill. Within the western part of West Bokaro the country is markedly undulating and the hills near Banji and Ghato rise about 300 ft. above the general level of the country which is over 1,000 ft. The same type of undulating country continues west of the Hazaribagh-Ranchi road up to the western end of the coalfield.

Hills

The low lying tracts covered with a soild cap are largely used for paddy cultivation whilst the comparatively undulating higher grounds are utilised for growing maize, *jowar*, etc. The upland country in the coalfield is covered with a jungle, sometimes thick, composed mainly of *sal* trees (*Shorea robusta*) which are largely used for mine timbering. Other trees include *Asan*, *Amla*, *Harla*, etc. At places patches of *Palas* (*Butea frondosa*) beautify the countryside with their red flowers during the spring time. These trees together with the plum trees (Hindi : *Bair* ; Beng. : *Kul* ; *Zizyphus jujube*) grown mostly close to human habitation yield certain quantities of lac, which constitutes an important trade of the area.

Flora

The hilly and wooded areas contain large and small game, such as tiger, bear and deer, while wild ducks are found sometimes in abundance in the Damodar river and in several *bundhs*. The coalfield is notorious for its containing several types of highly poisonous snakes of which the Krait is the most common.

Fauna

There is no town worth mentioning situated in the coalfield. Some of the villages like Jaridih, Hazari, Saram and Kuju are important centres of local trade. Bermo is the most important railway station in the area, where the important mining settlements at Dhori, Kargali, Bokaro, Sawang-Pipradih and Ghato constitute small townships of the field.

Towns

The population of the Bokaro coalfield consists of the majority of the aboriginal tribe of Santhals while some of the indigenous people include Banias, Potters and the cultivating class. The Bauris, most common in the Jharia and the Raniganj coalfields, are very rare in this area. The total population of the coalfield, according to the census of 1931, is 55,752. To this should be added an estimated floating population of about 19,800 constituting the labour employed in the various collieries.

Population

The climate of the Bokaro coalfield is, on the whole, farily healthy although there is incidence of malarial fever, especially during the latter part of the monsoon extending up to December or January. The average rainfall during the year varies from 48 to 52 inches. During winter the climate is dry and bracing, the maximum day temperatures scarcely exceed 80°F., while the night temperatures sometimes fall to 45°F. In summer the maximum temperature is above 100°F., sometimes rising to 110°F., and the night temperatures vary between 75°—80°F.

Climate

Water for human consumption in the Bokaro coalfield is supplied form rivers, springs, wells and from large tanks lying close to villages. In some collieries the requirements are met from the water stored in abandoned coal quarries. Wells sunk in the Gondwana sandstones usually give a good supply of water within reasonable depths and in some villages it has been noticed that wells have been located in fault zones where there is copious supply of water. The requirements of the Dhori colliery and the Government railway collieries at Kargali and Bokaro are met from the Damodar river in the bed of which percolation galleries have been driven, especially at Kargali, while the Sawang colliery gets its supply from the Konar river.

Water-Supply

Pumping stations are situated by the side of the respective rivers at Dhori, Kargali, Bokaro and Sawang. Supply of water to the Jarangdih colliery is made from an abandoned quarry in the colliery area while that to Pipradih colliery from a similar abandoned quarry belonging to the Sawang colliery. In West Bokaro area the main water-supply is from wells but in the Kuju colliery when the same was working, part of the requirement was met from the water pumped out from the underground workings. The West Bokaro colliery have made arrangement

for their water supply from wells and also from the Bokaro rever. For irrigation purposes water is obtained from numerous tanks and *bundhs* which have been made sometimes by damming small valleys and also raised from various streams and *nalas* which occur in the coalfield.

The Dumri-Bermo road, branching off from the Grand Trunk road about mile 202 near Dumri, enters the field in a north-south direction at Phusro, from where it traverses the eastern field in a general east-west direction and crosses the Konar river by a masonry and steel girder bridge at the Jarangdih station. Formerly it used to pass through the bed of the Bokaro river three miles from Sawang. This road links up with the Petarbar-Bishnugarh road at Gumia. In West Bokaro the Hazaribagh-Ranchi road passes through the western edge of the field. Between mile 12 and 13 from Hazaribagh a Mines Board road branches off from the main road at Charhi and is metalled up to Parej and thereafter *kutcha* up to Loiyo but motorable during the fair weather. After the West Bokaro colliery has been laid out, a road has been taken to Ghato from this road from a point lying between Parej and Banji. Also at mile 24 on the Hazaribagh-Ranchi road, a motorable road, has been taken out as far as Chainpur railway station.

Roads and ferries

During the dry season—November to May—the Damodar, Konar and Bokaro rivers can be crossed on foot. During the monsoon there are ferries across the Damodar river at two or three places but there is no arrangement for ferries in the Bokaro and Konar rivers.

The coalfield is traversed by the Eastern Railway branch line from Gomoh (previously known as the Central Coalfields Railway). From Chandrapura the line passes from east to west through Dhori, Kargali, Bermo, Jarangdih and Gumia and along the north of the Lugu Hill by the side of the Bokaro river and then south-west from Danea and through Chainpur to Ranchi Road station. It then crosses the Damodar river to Barkakana where it is joined by the Chandil-Muri-Ramgarh line of the South-Eastern Railway. Thus the East Bokaro area and the southern portion of the West Bokaro are served by a broad gauge line connecting with Calcutta and Daltonganj but the northern part of West Bokaro is yet to be served by a branch railway line.

CHAPTER III

GEOLOGY

The classification of the Gondwana rocks of Bengal, Bihar and Orissa, as revised by Dr. C. S. Fox (1930, p. 22) and now generally accepted, is as follows :

Upper Gondwana	Rajmahal Series	Basaltic lavas Plant beds
	Dubrajpur beds or Supra Panchets.	
	—Unconformity—	
Lower Gondwana	Panchet Series of Raniganj Damuda Group or Coal-bearing beds Talchir Series	
	—Great unconformity—	

Further sub-dividing with the more recent knowledge gained from the coalfields in this region, the succession of strata is given below :

Upper Gondwanas	Rajmahal with inter-trappean plant beds.	Lower Jurassic.
	Dubrajpur beds or Supra Panchets.	Rhaetic.
	—(? Unconformity)—	
Lower Gondwanas	Panchet stage	Bunter.
	Raniganj stage—Upper coal measures.	Upper Permian.
	Barren Measures	Middle Permian.
	Barakar stage with Karharibari beds—Lower coal measures.	Lower Permian.
	Talchir stage with glacial boulder bed.	Upper Carboniferous.

In the Bokaro coalfield the geological formations met with are as follows :

Post Gondwana Intrusive Igneous rocks.

Lower Gondwanas	Panchet Series		Upper Panchets Lower Panchets
	Damuda Series	Upper	Raniganj stage or Upper Coal Measures. Barren Measures containing Ironstone Shales facies.
		Lower	Barakar stage or Lower Coal Measures. Talchir stage.

Archaeans

ARCHAEANS

The Archaean rocks are found on all the four sides of the Bokaro coalfield and form the boundaries of the coalfield in all these directions. In the northern part inliers of Archaean rocks are sometimes found in the younger rocks. The Archaean-Gondwana boundary is a faulted one where a quartzose fault-breccia and also a jumbled up mass of rocks, namely, gneisses, a siliceous rock and a conglomeratic sandstone, are occasionally found. In some cases the pebbles of the conglomeratic sandstone have been badly broken and re-cemented. The boundary fault is aligned roughly in an east-west direction.

The Archaean rocks consist of granitoid gneiss with occasional inclusions of hornblende-schists, hornblende- and mica-gneiss and are often traversed by pegmatite and quartz veins of varying thickness. The Archaeans have been examined only near their junction with the Gondwanas and that also not in great detail.

LOWER GONDWANAS

The Lower Gondwana rocks represented in the area include the Damuda and the Panchet Series, both divided into lower and upper divisions. The lower Damuda division contains the Talchir and the Barakar or Lower Coal Measures stages while in the upper are included the Barren Measures containing the Ironstone Shales facies and the Raniganj stage or the Upper Coal Measures.

In West Bokaro the stage equivalent to the Barren Measures in part was mapped in the early stages as Ironstone Shales but by continuing the detailed strike-mapping of the rocks, especially sandstones in East Bokaro (a specimen of the strike-mapping is to be seen in Plate VIIA), it has been found that there are more than one facies of the Ironstone Shales separated by massive sandstones and micaceous-carbonaceous sandy shales or shaly sandstones absolutely barren of coal seams and these cannot be called as ' Ironstone Shales '. Hence the introduction of 'Barren Measures' has been found necessary to include the top portion of the Barakars, the Ironstone Shales and the lower portion of the Raniganj stage all containing no coal seams. The author had studied the Barren Measures of the Jamunia river and the Katri and Kudia rivers of the Mohuda area in the Jharia coalfield and found them to correspond with the Barren Measures of the Bokaro coalfield only with this small difference that the sandy shales of the Jharia coalfield are apparently more carbonaceous than the similar rocks in Bokaro.

DAMUDA SERIES

Talchir stage

The oldest formation included in the Damuda series occurring in the Bokaro coalfield is the Talchir stage, outcrops of which are found along the eastern, northern and western borders of the coalfield. No outcrops of the Talchirs, it may be noted, occur along its southern border. Small outliers of the Talchirs with the overlying Barakar rocks are sometimes found in the Archaeans. The rocks of the Talchir stage are

represented by a greenish boulder-conglomerate associated with a greenish sandstone at some places and overlain by fine silty shales of olive-green colour. So far no fossil has been found in the Talchir rocks. The Talchirs have attained a maximum thickness of 900 ft. in the Bokaro coalfield.

Chapri

The Talchir rocks are well exposed at Chapri (Plate I, Figs. 1 & 2) on both sides of the Dumri-Phusro motor road, about 6 miles by road from Bermo. The rocks consist of unassorted boulders and pebbles of various sizes, sometimes up to two feet across, embedded in a fine silty matrix of greensih colour as also fine greenish shales. The glacial boulder bed is in general 50 to 100 ft. thick. On the east of the motor road fine to medium grained greenish sandstones are also seen.

Ocho *nala*

An outcrop of the Talchirs, separated from the main mass of the Gondwana rocks by a narrow strip of Archaeans with mica-peridotite intrusions, is found along the northern border of the coalfield west of Ocho *nala*, about half a mile N. W. of Ocho (23°48′ : 85°48′). The rocks include a boulder bed and shales with associated shaly sandstones both of olive-green colour. In the boulder bed, big boulders, sometimes two to three feet across to small pebbles less than an inch in diameter, are embedded in a fine sandy matrix, the colour of which varies from greyish to faint greennish, but at places where the matrix tends to be coarser it is definitely greenish in colour. The boulders and pebbles, which are not so rounded as those found in the conglomeratic sandstones at the base of the immediately overlying rocks, the Barrakars, are usually of coarse-grained gneissose and fine-grained quartzitic rocks. No glaciated boulders have so far been found. Loose boulders are found scattered almost throughout the outcrop.

North of Barisam

A small triangular outcrop of the Talchirs is found north of Barisam (23°49′ : 85°32½′), where greenish boulder conglomerate is found. Small outliers of Barakar sandstones occur in this outcrop. Here the Talchir rocks are faulted against the Archaeans in the north and the Raniganj beds in the south.

Dudhi *nadi*

A fairly big exposure of the Talchir rocks is found in the Dudhi *nadi* spreading over the country north-west of Mandu (23°48′ : 85°28′). It continues eastwards, occupying the area between Baladhohar (23°48′ : 85°28½′) and Keke Basaudih (23°48′ : 85°30′) and then swings round in a southwesterly direction, crossing the Hazaribagh-Ranchi road between miles 18/2 and 18/6 and finally pinches out at mile 19/1.

The rocks include a boulder bed and shales with associated shaly sandstones both of olive-green colour. In the boulder bed, boulders varying in size from two to three feet across to small pebbles less than an inch in diameter, are embedded in a fine silty matrix usually of a greenish colour, but at places the matrix tends to be coarser in texture

though it possesses the same greenish appearance. As noted in East Bokaro the boulders and pebbles are generally of coarse-grained, gneissose and fine-grained quartzitic rocks and are not so rounded as those found in the overlying Barakars. No glaciated boulders have been found. Almost throughout the outcrop loose boulders have been found strewn on the surface.

The dip of the Talchir rocks varies from north-east through east to south-east, the amount of dip usually being 10° to 12°, greatly increasing near the faults.

Barakar stage

The major portion of the country in the Bokaro coalfield is occupied by the rocks of the Barakar stage or the Lower Coal Measures. The rocks consist of false-bedded sandstones, often coarse-grained, and sometimes conglomeratic, usually with rounded pebbles of white or grey quartz or quartzite, greyish flinty rocks and reddish and dirty greenish jasperoid rock. There are, however, instances in which angular pieces of a light brownish and ash coloured quartzose rock of a granulitic texture are also found. Interbedded with the sandstones are shaly sandstones, shales-carbonaceous, micaceous and ferruginous in minor proportion and seams of coal of different thickness and quality. Sometimes beds of fire-clay are found associated with the coal-bearing rocks and often underlying some coal seams.

Drilling work in West Bokaro has revealed the frequent presence of thin ferruginous bands in the Barakar succession. This is characteristically absent in the East Bokaro cyclothems. The author believes that this reflects the gradual advent of warm climate in the west during the Barakar times—the precursor to a general aridity of the overlying Barren Measures.

The dip of the rocks of the area is in a general southerly direction in the northern, westerly in the eastern, northerly in the southern part. Near the western end of the coalfield it swings round to form a basin, as is characteristic of coal basins. The amount of dip varies usually from 3° to 40°, but increases greatly near the faults.

Dr. Fermor (1917) has recognised 29 coal seams (including several under four feet in thickness) within the Barakars in East Bokaro and has made out the total thickness of the Barakars as 2,481 ft. The author is of the same opinion and considers the total thickness of the Barakar rocks to be 2,500 ft.

Of the workable coal seams in the East Bokaro area, the topmost is the Jarangdih seam (25 ft. thick) followed by the Amlo seam (10 ft. thick), the Kargali seam (40 ft. to 100 ft. or more in thickness), the Bermo seam (30 ft. to 40 ft. thick), an eight-foot seam and the Karo seam (maximum thickness 100 ft.). The Kargali seam is undoubtedly the best both in quality and in having caking properties. A bed of fire-clay, about 6ft. thick, is found underlying the top Karo seam, and is worked at several places. In the West Bokaro colliery area coals from seams 8, 9 and 10 have been proved to contain coking coals with good washing properties. Several other coal seams, some of which are quarriable,

occur in the West Bokaro area. The important seams amongst these are as follows :

Name of seam	Thickness
(i) Kuju seam	Nearly 35 ft.
(ii) Hesagora seam	25 „
(iii) Banwar seam	Over 30 „
(iv) Datma seam	Over 30 „
(v) Pindra seam	12 „

The details of the above coal seams are given in Chapters VIII and IX.

The shales of the Barakar stage contain, at some places, fairly well preserved plant fossils, the most common of which are *Glossopteris* sp and *Vertebraria indica.*

The Barakar rocks, besides being affected by the East-West boundary faults, are traversed by several cross and oblique faults, sometimes with appreciable downthrows.

'Burnt outcrops' of coal seams and baked and fused strata are found at several places, *e.g.*, between Kargali and Sawang, particularly in the low hills south and south-west of Uchitdih (23°45 ½ ′ 85°52 ½′), in the hill half a mile S. 10° E. of Kedla (23°48′: 85°35 ½′), hills west and S. S. W. of Loiyo (23°47½′ : 85°38½′), at and around Duru Kasmar (23°48½′ : 85°33′), between Parej (23°48½′: 85°32½′) and Sunughututoli (23°47¾′ : 85°32′) and around Bhutahitoli (23°47½′ : 85°32′). The occurrence of 'burnt outcrops' may be regarded generally as a good indication of the presence of coal of superior quality. The 'burnt outcrops' have been specially dealt with by L. L. Fermor (1928, p. 52).

Barren Measures stage

The Barren Measures occupy fairly big areas in both the East and the West Bokaro areas. In East Bokaro, these are found extending westwards from east to Hazari (23°47′ : 85°51½′) through Mianbandh (23°47′ : 85°48½′), Dhende (23°47′ : 85°47½′), Birsa (23°47¼′ : 85°47′), Gose (23°-48½′ : 85°46′) and Koiyotanr (23°48′: 85°45′). There is also a small strip of Barren Measures just west of the Sindurdaha *nala*, S. S. W. of Khudgara (23°47½′ : 85°50½′). Here the Ironstone Shales are apparently overlying the Raniganj sandstones to the east ; this apparent position has been brought about by a fault coincident with the *nala*. The rocks consist of carbonaceous shales containing nodules, sometimes linear lenticles and bands of clay-ironstone (ferruginous), usually limonitic.

The Barren Measures are found in West Bokaro in two small outcrops, one south and E. S. E. of Basantpur (23°49′ : 85°34′) and the other E. N. E. of Duni (23°46¼′ : 85°33′), while they occupy an area westwards practically from the Hazaribagh-Ranchi road between milestones 20 and 21/6 and terminating near Bhurkunda (23°44½′ : 85°25½′) near the western end of the coalfield. The rocks include sandstones, shaly sandstones, carbonaceous shales, micaceous-carbonaceous sandy

shales, etc., and contain at least two facies of Ironstone Shales, with linear bands and lenticles of clay-ironstone, usually limonitic. The ironstone nodules exhibit spheroidal weathering and some are found to contain plant fossils, such as equisetum stem, *Glossopteris* sp. and some badly preserved plant remains. The ironstones do not occur in quantity so as to be economically workable for use as ore of iron.

The total thickness of the Barren Measures in this area has been computed to be 2,750 ft.

Raniganj stage

The rocks of the Raniganj stage or the Upper Coal Measures occupy the eastern and northern flanks of a basin, the centre of which is occupied by the Lugu Hills, and are cropping out near Kodwatanr (23°45′ : 85°47½′), Kharwatanr (23°45′ : 85°48′), Pindratanr (23°46′ : 85°48′), south of Dhendhe (23°47′ : 85°47½′), Tulbul (23°47′ : 85°46′) and Kusumtoli (23°47¼′ : 85°45½′) (sheet 12). They continue westwards to Pindra (23°47¼′ : 85°45′) (sheet 11). Also in West Bokaro a small wedge-shaped outcrop is found east of Taping (23°50′ : 85°30′). It extends through Barisam (23°49′ : 85°32½′) and Basantpur (23°49′ : 85°34′) and is faulted against the Archaeans in the north and Barakars in the south.

The rocks consist of fine to medium-grained light greyish coloured sandstones sometimes with a greenish tinge and shales. They contain some coal seams varying in thickness usually from one foot to a maximum of 6 ft. excepting in one case wherein it is found to be 10 ft. The sandstones are often thin-bedded and are definitely finer grained than those of the Barakar stage.

The dips of the rocks are usually at medium angles but close to the faults, which have also affected these rocks, the beds dip steeply at angles of over 70°.

The Raniganj beds in the Bokaro area have attained a maximum thickness of 1,500 ft.

The coal seams are usually inclined at high angles seldom below 70°—in the eastern portion near Kharwatanr. In the northern portion the dip becomes much lower, varying from 35° to 45° north-east of Kusumtoli and 10° to 15° in the seams cropping out in the right bank of the Bokaro river, north and east of Pindra.

PANCHET SERIELS

Lower Panchet stage

The lower Panchet rocks rest with a slight unconformity (evidence so far obtained) over those of the Raniganj stage and consist of sandstones, generally of a brownish or greenish-grey colour and more micaceous than the Raniganj sandstone. The lower Panchet sandstones, which resemble at times some of the sandstones of the immediately underlying stage, are often false-bedded and are interbedded with greenish to greenish-grey shales and shaly sandstones. The latter rocks resemble certain types of Talchir rocks. Associated with the greenish

shales in the Dhardharia *nala*, north-west of Kodwatanr (23°45′ : 85°47½′), some thin bands of purple shales are also found. Near the Raniganj-Lower Panchet boundary in the *nala* meeting the Dhardharia *nala* at a point north-east of Kodwatanr, greenish-grey shales intercalated with sandstones contain plant fossils which are rather badly preserved but could be identified as equiseum stems. Similar occurrences of plant fossils in the Lower Panchets have been mentioned by E. R. Gee (1932, p. 59) in his Raniganj Coalfield Memoir.

The lower Panchet rocks appear to have attained a maximum thickness of 4,900 ft.

The soil resulting from the disintegration of the Lower Panchet rocks is of a light brownish colour.

Upper Panchet stage

The upper Panchet rocks are cropping out in the Lugu Hill area and consist of sandstones with intercalated red clays and shales. The sandstones are usually light greyish to yellowish in colour, soft and medium textured and are often current-bedded. Huge blocks of the Upper Panchet rocks broken down from the main mass in the Lugu Hills are found lying scattered over the Lower Panchets and in the Bokaro river in the country from one mile west of Pindra to Tutijharna (23°48′ : 85°42′). No fossils have been found in the Upper Panchet rocks.

The maximum thickness of the Upper Panchet beds, as developed in the Bokaro coalfield is 1,400 ft.

SIGNIFICANCE OF COAL DISTRIBUTION

Although the sedimentary sequence of the Bokaro basin described above is similar in broad pattern to that of the adjoining easterly coal basins of Jharia and Raniganj, there are subtle and progressive changes in the character and assemblage of the sedimentary columns. From east to west, the following coal basins are met with in succession : Raniganj, Jharia, Bokaro and Karanpura. A comparative study of the amount of the carbon amongst the three first named coalfields reveals—

(i) an overall increase in the carbon ratio of the Barakar stage towards the centrally located Jharia coalfield ;

(ii) an overall increase in the abundance of the carbonaceous shale units in the Barren Measures towards east; and

(iii) a progressive dwindling of the coal seams of the Raniganj stage towards west.

The above features are by no means valid in all dimensions and localities and are in the nature of salient generalisations.

Present evidences indicate that the different Gondwana coalfields of the Damodar Valley, which to-day lie separated as blocks within the Archaean metamorphics, were initially in the nature of a continuous sheet. Hence the overall migration in the abundance of carbonaceous matter from west to east, as one goes up the stratigraphic column, possibly reflects progressive eastward migration of the woodlands in the sedimentary provenance during the Gondwana period. In this connection, E. R. Gee's (1932 p. 52) conclusion regarding sedimentation

in the Raniganj coalfields is worth noting. " It seems probable that at least during the early part of the Damuda period (*i.e.*, Barakar times) the general direction of drainage of these low-lying swamps and lacustrine tracts was from east to west. This is suggested by the fact that coal seams are more numerous and of greater thickness to the west, the heavier inorganic rock materials being deposited in the eastern portion of the field and the lighter mother substance of the coal being carried further west into the middle and western Raniganj and the more distant Jharia areas. " This, however, runs counter to the findings of Fox (1930, p. 22) in the Jharia coalfield who concluded from structural and lithological considerations "that the great gneissic plateau was traversed by wide valleys or river plains through which the drainage of Gondwana times meandered outwards towards the Assam valley and towards the delta of the Brahmaputra. The coalfields of Sambalpur and Orissa further suggest that there was also an outlet towards the Bay of Bengal. This is conjecture of course, but it is supported by the fact that marine Upper Palaeozioc fossils have been found below Damuda rocks in the Daphla and Abor country of Upper Assam and that marine Upper Palaeozioc rocks occur in the Shan States of Burma ".

As a corollary to the postulate of E. R. Gee, a sympathetic lateral variation in *shale : sand* ratio along with increase in carbonaceous matter should have been recorded. Such features are, nowhere, prominently displayed.

The author is of the opinion that enrichment of coaly matter should not be taken as a reliable indicator of drainage pattern. Palaeocurrent studies are necessary to unravel the direction of drainage during Gondwana times.

POST-GONDWANA INTRUSIVE IGNEOUS ROCKS

The area is traversed by several dolerite dykes, mica-peridotite (lamprophyre) dykes and sills and also by an acid variety of rock of the aplitic type of varying thickness. The dolerite dykes are cutting through the Archaeans, Barakars, Barren Measures, Raniganj beds and the Lower Panchets while the mica-peridotites are found intrusive commonly in the Barakars but also in the Barren Measures and in the Archaeans near their faulted junction with the Barren Measures (sheet No. 5). There is one instance so far noticed whrere a mica-peridotite dyke has intruded into the Lower Panchet rocks in sheet No. 4. Dykes of the applitic rock are noticed in the Talchirs and the Barren Measures in sheet Nos. 1 and 8.

CHAPTER IV

IGNEOUS ROCKS AND STRUCTURE

Intrusive Igneous Rocks

It has already been mentioned in the previous Chapter that three main types of intrusive igneous rocks are cutting through both the Archaeans and the Gondwana rocks. The rock types include dolerite, mica-peridotite (lamprophyre) and an acid variety of rock of aplitic composition. While the first and the last types occur as dykes only, the mica-peridotites occur both as dykes and sills, all of which vary greatly in thickness. The dolerite dykes have a thickness going up to a maximum of 51 ft. while the other intrusions are generally of small thickness of not more than 5 ft. The effects of the dolerite intrusion are not usually perceptible while those of the mica-peridotite intrusion fortunately are not disastrous. Some of the mica-peridotite dykes have been so decomposed and silicified that the resulting rock is likely to be mistaken for an aplitic rock. The dolerite dykes have a general N.E.—S.W. trend while the others run in different directions.

Jarangdih Quarry

Dolerite dykes

In East Bokaro there is a prominent dolerite dyke which cuts across the Damodar river N.N.E. of Pichhri (23°45′ : 86°1½′) and continues in a north-north-easterly direction along the Tisri *nala* up to Barkaberatoli (23°47½′ : 86°02′). A small dolerite dyke is also met with east of the main dyke, in the Karipani *nala* cutting through the Karo seam.

The trend of the dolerite dyke east of Phusro railway station is approximately parallel to the N.N.E. trending faults of the area. It is quite probable that the dyke has followed a weak zone of faulting as its channel of movement.

In the West Bokaro a dolerite dyke about 14 ft. wide runs east- north-eastwards from east of Makundaberatoli (23°46½′ : 85°34′) to just N.N.W. of Lartengritoli (23°46½′ : 85°35′) and again appears after a short break, E.N.E. of the latter village.

There is a prominent dolerite dyke aligned in an E.N.E.—W.S.W. direction and running for more than two miles north of Dhewthatanr and Daka Saram (sheet No. 10). Also another dolerite dyke cuts through the Lower Panchets and the Barren Measures (sheet No. 3).

A dolerite dyke worth noting is also seen running almost east-north-eastwards through Daru Kasmer (sheet No. 2). Two prominent dolerite dykes, one east of Nauniaberatoli (23°49½′ : 85°29½′) and the other north of Bhurkunda (23°44½′: 85°25½′) occur as intrusive in the Barakar rocks. The one east of Nauniaberatoli is aligned in N.E.—S.W. direction and is 51 ft. in width as noted in the Bokaro river, while the other runs roughly in an east-west direction and appears to be over 25 ft. wide.

None of the dykes has intruded into coal seams and hence no damage is done to the coal.

Mica-peridotite intrusions

The mica-peridotites occur both as dykes and sills and have been found cutting commonly through the Barakar and rarely the Barren Measures and Lower Panchet rocks. No generalisation could be made about the direction in which the mica-peridotite intrusions are running ; in fact, these intrusions are found aligned in all possible directions.

In the Kargali area there are three almost parallel east-west dykes of which the middle one is of mica-peridotite. The other two dykes are of a fine-grained acidic type of rock, the colour varying from whitish and light greyish to light brownish. In hand specimens it looks like an aplitic rock but observations in different parts of the field have led to the conclusion that it is an altered and silicified mica-peridotite, especially as it occurs in the continuation of the strike of, and sometimes in between two portions of a mica-peridotite dyke. At Kargali proper the rocks in question do not contain much mica and there is nothing to indicate that they belong to the mica-peridotite type but a close observation of similar types of rocks in the Jarangdih colliery has revealed a gradation from the mica-peridotite to an acid type of rock containing a fair quantity of mica of the original mica-peridotite still intact. After much careful consideration, it appears fairly certain that the acid type of rock is nothing but altered and silicified mica-peridotite.

These intrusive rocks are classed under the general term "mica-peridotites" but actually they are neither mica-peridotites nor mica-traps. They are in fact mostly mica-lamprophyres—generally olivine and leucite-bearing minette and kersantite of the lamprophyre group. Some portions of the dykes are occasionally very rich in olivine and biotite with practically no felspars, so that they might better be called as biotite-peridotite. The lamprophyres at times also contain such other minerals as pyroxene and amphibole. These rock types appear to be the same as described from the Jharia (Ghosh, 1949) and the Raniganj (Banerjee, 1953) coalfields.

Only one mica-peridotite dyke has been found intrusive into the Lower Panchets and it occurs six furlongs W.N.W. of Pindra on the Tulbul-Tutijharna cart road and is two ft. wide.

Intrusions of mica-peridotite are rare in the metamorphic rocks (Archaeans). Two small intrusions of this material are found in the Archaeans near the faulted junction with the Barren Measures in the Ocho *nadi* and in a small tributary of it, N.N.W. of Ocho (23°48½′ : 85°48¼′).

The effects of the mica-peridotite intrusions generally are not so disastrous on the coal as one may naturally apprehend ; but in certain cases, as also proved in some boreholes, the coal seams have been seriously affected at places. The damage to coal is usually confined to about double the thickness of the dyke, *jhama* and coke sometimes with columnar structure having been formed on both sides of the intrusion. A white saline efflorescence is generally noticed at the junction of the dyke with the coal (Pl. IV, Fig. 1).

Aplitic dykes

Dykes of a siliceous material approaching an aplite are noticed cutting through the Talchir rocks west of the Bokaro river, east of the milestone 15/1 on the Hazaribagh-Ranchi road (sheet No. 1), and the Barren Measures in the Bahera *nadi*, south-east of Keribanda (23°45½′ : 85°28½′—sheet No. 8).

Age of the intrusions

No lava flows indicating the extensive phase of the intrusions have been met with in the Bokaro coalfield. The lower Gondwana rocks are presumed to lie deeply buried under the upper Panchet rocks at the time these intrusions had taken place. The dolerites are considered to be equivalents of the Rajmahal traps of not older than Lower Jurassic age as suggested by Blanford (1861, p. 149), although Fox (1930, pp. 113-114) had later pointed out that these might also belong to the Deccan Trap age. The dolerite dykes are unaffected by the several faults, thereby proving that they are of post-fault period.

The mica-peridotite intrusions are closely associated with the earth movements as in certain cases they have been affected by the faulting. It should also be noted here that in the majority of the cases these intrusions have taken place after the displacement. It is, therefore, reasonable to assume that the dolerite intrusions are of a slightly younger age than the mica-peridotites.

Mechanism of magma emplacement

The intensity of magmatic intrusion in the Damodar Valley coalfields shows a steady decrease towards the west. Thus in the easternmost Raniganj coalfield, lamprophyres are extremely abundant in the coal measures and the total exposed length of the dolerite intrusions is more than 55 miles. In the adjoining westerly coalfield of Jharia, lamprophyres are moderately abundant and the total exposed length of the dolerite dykes is 23 miles approximately. In the Bokaro basin to its west, both the lamprophyres and the dolerites have diminished in abundance, the latter having a total exposed length of 11.5 miles approximately. Since the petrographic examination of these igneous suites indicates an overall similarity within their clans, the author is of the opinion that the original magmatic chambers from which these rocks were derived possibly lay nearer the eastern basins, perhaps connected with the lower Jurassic Rajmahal magmatic episode.

The style of magmatic intrusion in the Damodar valley coalfields striking in view of—

(i) the complete absence of dolerite in sill forms ;

(ii) the rarity of lamprophyre sills in any rock other than the coal seams.

The absence of dolerite in sill forms indicate that channel ways parallel to bedding were absent, due probably to the absence of a radial tension within the sediments, during the period of intrusion. To all appearances, strong radial tension at right angles to the low dipping beds was also absent during the period of lamprophyre intrusion.This is reflected by the rarity of lamprophyre sills in the sandstones and shales of the Coal Measures. The interbedded coal seams were, however, much less competent even in the absence of a radially directed tensional

force. While travelling along the deep-seated fault and fracture planes, the lamprophyric magma reacted against this incompetent unit and spread itself laterally along the seams. The preferential distribution of lamprophyres in the coal seam horizons is the expression of a complex of structural incompetency, extreme fluidity and high temperature.

In this connection, it may be worth while to mention that in general the abundance of lamprophyric intrusion is directly proportional to the quality of coal, *viz.*, the better the quality of coal, the greater the intrusion of lamprophyre ; or in other words, the less the amount of foreign matter, mostly argillaceous sediments, the more the intrusion. Since shale is more competent than coaly matter, shaly admixtures in coal increase the relative competency and thereby prevent intrusive tendencies. It is quite possible that the distribution of lamprophyre is controlled by delicate variations in competency within the coal seams. Such a structural control requires a high degree of fluidity for the magma which is corroborated by other petrographic and structural evidences.

Faults

Besides the great east to west boundary faults lying on the northern and southern borders of the Bokaro coalfield several important faults traverse the area in a general east-west direction. Quite a number of cross and oblique faults are also found. Of the faults, the more important ones are the Gobindpur-Pichhri, Dhori-Pichhri, Borea and Kathpara faults in East Bokaro and Banji and Duni faults in West Bokaro. So far as could be ascertained from the field observations and borehole records the Gobindpur-Pichhri fault has the greatest downthrow and that in a southern direction. This fault is distinctly seen in the southern side of quarry No. 6 of the Bokaro colliery. This fault has thrown down to great depths many of the coal seams as will appear from the borehole records in the Dhori and Jarangdih areas. The Bhalugarha and the Duni faults have met about half a mile E.N.E. of Garkia (Parsabera) (23°46′ : 85°35′) and have their downthrow sides on their east and south respectively. The effect of these two faults has been that the country east and south of them have sunk several hundred feet so that the beds here are stratigraphically much higher in series than in the country west and north of them. The effects of the faults will be discussed in detail when dealing with the areas separately.

Faults have affected generally adversely the coal seams of the area. Besides breaking the continuity of the coal seams, they have increased in varying degrees the inclination of the seams, more particularly in the portions lying close to them. The faults have increased the difficulties of mining and in some cases areas have been so very badly affected by them as to render them unsuitable to be worked.

The faults of the Bokaro coalfield are mostly of the normal type. As stated above, fault surfaces within the coalfield are diversely oriented and vectors of tension, plotted at right angles to the strikes of the normal faults make a complicated pattern in the sedimentary basin. In the opinion of the author, the active tensional forces in Bokaro and the adjoining coalfields were oriented in a north-south plane. Structural inhomogeneity between the basement Archaeans and the Gondwana sediments on the one hand and among the shale—sand stone—coal rock

types within the sediments on the other, gave rise to the irregular pattern of cross and oblique faults within the coal basins.

Fox has invoked active east-west compressional forces as a satisfactory explanation for the pattern of outcrops in the Jharia coalfield. The style of deformation in the adjoining coalfields of Raniganj to its east and Bokaro to its west are, however, dominantly tensional in nature and at the first appearance, compression in the Jharia coalfield in the middle does not fit in with the tectonic style of the neighbours. There is reason to believe that the deformation history of the Damodar Valley coalfields was more or less similar all throughout its extent. The author believes that the compressional element in the Jharia coalfield is a passive component caused probably by the irregular competent Archaean promontories lying within and between the coal basins. The duality of compression and tension in the Jharia and partly in the Raniganj coalfield can thus be satisfactorily explained.

Folds

The East Bokaro area has not been subjected to any folding. Some local crumpling and puckering are noticed in the shales overlying the top Karo seam on the right bank of the Damodar river E.S.E. of Phusro railway station (23°46′ : 86°01′) in sheet No. 14. The sandstones lying above and below the shales and the coal seams, however, do not appear to have been folded in any way. In the West Bokaro area also there is not much folding excepting north-west of Kedla (23°47½′ : 85°35½′) where the strata are locally folded into an anticline and a syncline, the maximum dip of the limbs of the folds not exceeding 10°.

Age of the faults

Fox (1930, p. 159) has stated that the faulting and folding movements to which the Jharia coal basin was subjected are possibly Jurassic or later in age. Similarly, in the Raniganj coalfield, Gee and his collaborators have proved that the major displacements, affecting as they do the Lower Gondwanas and Supra-Panchets alike, took place during Jurassic times.

The style of faulting in the Bokaro coalfield is similar to those of the adjoining basins and a perusal of the geological map (Pl. VII) will show that shearing movements have affected all the horizons from the Talchir to the Lower Panchet stage. Evidences of faulting movements are scarce in the Upper Panchet sedimentaries around the Lugu Hill and the author feels that minor displacements which are hard to detect in the absence of index interbands may well be present in this stage.

Assuming from their similarity in style a synchronism amongst the majority of the displacements in the Bokaro coalfield, the faulting movements are found to be post-Panchet in age and they overlap in time with the lamprophyric intrusions.

PART II

CHAPTER V

DESCRIPTION OF THE COAL SEAMS IN THE BARAKAR MEASURES, EAST BOKARO

In the East Bokaro coalfield all the important coal seams lie entirely in the B rakar series, which usually rest directly on the Archaean rocks, but sometimes a small thickness of Talchirs intervenes. Several coal seams, some of which attain thickness of 100 feet and over, are noted in this area. Of these seams the ones cropping out in the extreme eastern part are rather inferior in quality. The more important coal seams in downward succession are as follows :—

Name of seam.		Thickness in ft.
Jarangdhih seam	..	20
Amlo seam	..	11 (maximum)
Kargali seam	..	120 (maximum)
Bermo seam	..	over 32
Karo seam	..	nearly 100

Of the above the Kargali seam is the best and of outstanding value and contains good coking coal. Several collieries, the majority now owned and managed by the Indian Government Railways, are worked in this area. Bokaro and Ramgur, Ltd. (Managing Agents—Messrs. Anderson, Wright & Co. of Calcutta) hold the prospecting licence for whole of the Bokaro coalfield and own both the easternmost and the westernmost collieries, namely the Dhori and the Pipradih collieries, in East Bokaro. The chain of Government Railway collieries, of which Kargali is the easternmost, commences from the western boundary of the Dhori colliery. The Bokaro colliery is situated immediately to the west of the Kargali colliery ; next to this with a gap of nearly half-a-mile is the Jarangdih colliery. West of the Jarangdih colliery there is again a gap of over four miles up to the next Government Railway colliery of Sawang. The Pipradih colliery is situated just west of the Sawang colliery. During the World War II much activity was noticed in this field and a fair percentage of the production during the stress period came from the collieries of this area.

1. KARO SEAM

East of Bermo-Dumri motor road

The Karo seam is the most prominent of the coal seams that crop out in the area east of the Bermo-Dumri motor road extending as far as north of Turio (23°45′ : 86°02½′). Eastwards of the above road continuing through north and east of Phusro railway station (23°46′ : 86°01′) and

extending up to the junction of the Tisri *na a* with the Damodar river, the Karo seam is split into two seams namely, the Top Karo and the Bottom Karo with a parting of varying thickness, and these two continue as two separate seams westwards also from the road as far as the outcrops can be traced. The two seams can be traced in the hill north-west of Phusro station continuing through north-north-east of it where old workings in the Top Karo are visible to this day and in the Damodar river from its junction with the Phusro *nala* to that with the Tisri *nala*. In the former area the seams have a south-westerly dip at about 8° while in the latter these have a general southerly dip at angles varying from 20° to 40°. Several faults as also a mica-peridotite dyke close to the mouth of the Ghora Garha *nala* and a dolerite dyke along the Tisri *nala* have affected the seams. The outcrop in the Damodar river, from its junction with the Phusro *nala* to that with the Tisri *nala*, has been worked from January, 1945.

Siladhar hill area

East of the Rajabera-Makoli cart track, which runs almost parallel to the Tisri *nala* and at right angles to the Chandrapura-Barkakana railway line, the two Karo seams have fused to form a thick seam about 100 ft. thick. This seam is seen for the first time, in the bed of the Damodar, from where the dip swings round east-wards and forms a basin below the Siladhar (△1087) hill. The Karo seam is found in the Dubiabera *nala*, dipping east-south-east at 20° ; east-south-west of Makoli (23°46½′ : 86°02′) it dips south-south-west at 5° to 10° and north of Turio (23°45′ : 86°02½′) in the hillside, it has a westerly dip of 10°. The outcrop at the last named place is terminated by an almost north-south fault lying immediately to the east. The coal is reported to have been worked during World War I and in fact an abandoned quarry exists at the foot of the hill, one mile north of Turio. The Karo seam was exposed in the hillside continuing down into the quarry for sampling, and the total thickness sampled was 98 ft. 11 inches. The following are the details of the section exposed giving ash content of each individual band and the proximate analysis of the whole seam excluding shale and *matti* bands :—

Karo seam—one mile north of Turio

Description	Thickness Ft.	Thickness In.	Ash Per cent.	Colour of ash
CARBONACEOUS SHALE ROOF				
Coal, shaly	1	3		
Coal	4	0	17·14	Buff pink
Coal, shaly	1	0	25·50	Vinaceous pink
Coal	1	2	21·58	Cream buff
Coal	1	7	17·76	Pearl grey

Karo seam—one mile north of Turio—contd.

Description	Thickness Ft.	In.	Ash Per cent.	Colour of ash
Coal, shaly (with two thin intercalated shale bands) . . .	2	9	39·28	Vinaceous buff
Shaly band*	0	5		
Coal	3	3	27·22	Pearl grey
Shaly band*	0	3		
Coal	0	7	34·10	Pearl grey
Shale band*	1	6		
Coal	1	2	20·36	Pinkish buff
Shale band*	0	7		
Coal	4	2	21·66	Pinkish buff
Pyritic *matti* band* . . .	0	3		
Coal	2	0	21·20	Pinkish buff
Shale band*	0	8		
Coal (including 3″ shaly coal in the middle)	1	10	25·40	Pinkish buff
Shale band*	0	5		
Coal	5	4	27·16	Plumbeous
Shale band*	0	7		
Coal	1	3	35·88	Light Ecru drab
Shale band	1	8		
Coal	5	0	30.84	Light Ecru drab
Shale band* (fireclay ?) . .	4	0		
Matti band*	0	7		
Coal (including ½″ *matti* band) .	4	9	26·12	Grey
Shaly coal*	0	8		
Coal	1	6	29·00	Light Ecru drab
Shale*	3	6		
Coal	2	0	24·20	Grey
Shale & Shaly band* . . .	3	4		
Coal	1	2	40·08	Grey
Shale*	0	6		

Karo seam—one mile north of Turio—contd

Description	Thickness Ft.	In.	Ash Per cent.	Colour of ash
Coal	0	8	43.84	Ecru drab
Shale*	1	5		
Coal	2	9	28·56	Grey
Shale*	3	0		
Drifted material				
Coal, decomposed* (not tested) .	7	0		
Shale*	0	11		
Coal	3	9	21·16	Greyish white
Shaly coal and drift band* .	1	0		
Coal	3	2	26.60	Grey
Shale band*	0	2		
Coal	2	0	25.26	Grey
Matti band	0	3		
Coal	3	7	26·52	Plumbeous
Shaly band*	0	4		
Coal	4	3	27.88	Pearl Grey
Total	89	11		

CARBONACEOUS SHALE FLOOR

The proximate analysis of the whole seam excluding the bands marked * is :—

	Per cent.
Moisture	5·20
Ash	26·08
Volatiles	21·50
Fixed carbon	47·22
	100·00

Calorific value of the coal	5,610 calories, or 10,000 B.t.u.
Nature of the coal	Non-caking.
Colour of the ash	Lavender grey.

Bokaro & Ramgur Ltd. have carried out washability tests on the Karo seam coal but the results, it is understood, are not encouraging.

West of Bermo-Dumri motor road

As mentioned above, the Karo seams (Top and Bottom) continue westwards from the Bermo-Dumri motor road up to longitude 85°55½' east of the Gobindpur fault. The seams show variation in dips both in direction and amount—while they are south-westerly at 15° immediately west of the motor road they swing round to the west further north where the amount is 10°. In the areas north of the Dhori, Kargali and Bokaro collieries, outcrops of the Karo seams have been traced as far as the Bokaro *nala* till intercepted by a N.N.W.—S.S.E. fault. The dips of the seams are in a south-westerly direction, while the amounts of dip vary from 8° to 10°. After a gap of nearly three-fourths of a mile the seams can again be traced in the Godo *nala* near its junctions with the Satsimra and Sutopani *nalas*, where the direction of dip has changed to south-south-east, the amount of dip being 10°. The seams can not be traced further west until on the other (western) side of the Gobindpur fault where outcrops of the Top and Bottom Karo seams are found east of the Konar fault, dipping S.S.W. at 25°. West of this latter fault the two Karo seams have coalesced to form one composite seam, 50 feet thick, maintaining the same direction of dip with a slightly lower angle varying from 20° to 23°. Further west no Karo seam outcrop is seen.

Sawang area

Although the Karo seams have not been sampled at different places except north of Turio, from the general look of the coals it appears that both the Karo seams contain coal of inferior quality. The coals are quarriable down to suitable depths excepting in the Gobindpur and Sawang areas where they do not appear to be so on account of rather high dips.

Quarriable depths

While estimating the reserves of coal in the different seams it will be worthwhile to give a careful consideration to the depths to which they can be quarried economically. Previously in normal times, the seams used to be considered as economically quarriable to a depth with overburden not exceeding the thickness of the seam itself. During the world War II, this, however, was found to be too conservative to meet the situation and removal of overburden amounting to twice the thickness of the seam, sometimes even more, has been carried out to meet the requirements. Thus it is seen that the pre-war idea regarding quarriable depths has undergone considerable change. Naturally this depends not only on physical and technical considerations but is also largely influenced by the nature and urgency of the purpose for which the material is intended. Consequently. both technical as well as economic factors will have to be given equal importance in the decision of the quarriable depths. Accordingly in view of the above considerations the reserves of the coal seams have been calculated on the assumption of different thicknesses of overburden in relation to the thickness of the seam.

Reserves (Karo seam)

The quantity of quarriable coal from the Karo seam is as follows :—

Quantity of quarriable coal from the Karo seam in East Bokaro coalfield

Name of area.	Average thickness in ft.	Average dip.	Reserve in tons. 1 With overburden equal to the thickness of the seam.	Reserve in tons. 2 With overburden twice the thickness of the seam.	Reserve in tons. 3 With overburden thrice the thickness of the seam.	Reserve in tons. 4 Down to specified depths.	Remarks.
Siladhar hill area . .	100	10°				61,840,000	Area basin shaped under the hill.
Between Siladhar hill and Phusro area	85	20°	2,123,000	4,246,000	6,369,000	10,900,000	Down to a depth of 435 ft.
Phusro area . . .	60	15°	5,064,000	10,128,000	15,192,000	31,560,000	Down to a depth of 355 ft.
Dhori area . . .	60	12°	5,064,000	10,128,000	15,192,000	81,370,000	Down to a depth of 1,400 ft.
Kargali-Bokaro area— Top seam . . .	25	8°	2,042,000	4,084,000	6,126,000	6,126,000	Down to a depth of 125 feet.
Bottom seam . .	30	9°	3,119,000	6,238,000	9,357,000	111,400,000	Down to a depth of 1,600 feet.
Gobindpur area . .	50	25°	..	..	..	50,000,000	Down to a depth of 2,600 feet.
Sawang area . . .	50	22°	..	..	..	50,000,000	Down to a depth of 2,000 feet.
		Total	17,412,000	34,824,000	52,236,000	403,196,000	

2. BERMO SEAM

Siladhar hill area

The Bermo seam overlies the Karo seam and is found to extend as far east as the Siladhar hill where this also has the shape of a basin, the western limb of which crops out in the Damodar river around its junction with the Hirgarha *nala* and closely follows a *nala* in the north. Its eastern limb crops out in the Kasmakocha *nala* and continues in an east-north-easterly direction till finally cut off by the same fault which similarly affects the Karo seam. No outcrop of the Bermo seam exists in the easternmost region ; but the seam was located in a well dug at Turio (north of village) by the local pepple.

Dhori colliery area

After a small gap between the Siladhar hill and the Bermo-Dumri motor road to the west the Bermo seam outcrop is found west of the road in the Dhori colliery area where underground mining, which had been carried out previously but was later discontinued, as also quarrying was commenced from 1944. The direction of dip of the seam varies from west through west-south-west to south, the amounts varying from 8° to 15°. The section of the Bermo seam in the Dhori colliery together with the analytical results is given below :—

Bermo Seam-Dhori Colliery

Description	Thickness		Ash	Colour of ash
	Ft.	In.	Per cent.	
SHALE ROOF				
Decomposed coal, shale, etc.*	8	4		
Shale with thin films of coal*	2	10		
Coal	1	2	25·24	Grey
Ferruginous & shaly band*	0	4½		
Coal	0	11	21·90	Ecru drab
Shale*	0	3		
Coal, shaly at places	6	4½	31·24	Pearl grey
Shaly band*	0	7		
Coal	0	11	26·76	Lavender grey
Shale band*	0	3		
Coal, bony & shaly	1	10	35·68	Plumbeous
Shale band*	0	5		
Coal	4	0	33·68	Plumbeous
Total	28	3		
CARRONACEOUS SHALE FLOOR				

The proximate analysis of the average sample excluding bands marked * is :—

	Per cent.
Mositure	0·68
Ash	30·16
Volatiles	21·58
Fixed carbon	47·58
	100 00

Calorific value of the coal	5,645 calories/10,160 B.t.u.
Nature of the coal	Caking.
Colour of the ash	Plumbeous.

Kargali and Bokaro areas

West of the Dhori colliery area the Bermo seam crops out in the Kargali and the Bermo colliery areas. At the former area the Bermo seam is exposed S.S.E. of Budkaro village (23°47′ : 85°58′) where quarrying was commenced by the Indian Government Railways from 1944. The seam dips S.S.E. at 7° and has a total thickness of 28 feet 11 inches. The section of the seam together with the proximate analysis of the average sample is as follows :—

Bermo Seam—Kargali Colliery

Description	Thickness Ft.	Thickness In.	Ash Per cent.	Colour of ash	Nature of coal
SHALE ROOF					
Decomposed coal and *matti* (not tested)* .	2	0			
Matti band* . .	0	6			
Coal, shaly . .	0	7	37·40	Ochraceous buff.	Caking.
Shale band* . .	0	1			
Bony coal . .	0	7	37·50	Grey . .	,,
Coal . . .	0	10½	23·20	Pearl grey .	,,
Matti band* . .	0	3			
Coal . . .	2	7	30·20	Grey . .	,,
Shaly band* . .	0	11			
Coal . . .	1	8½	18·00	Pearl grey .	,,
Matti band . .	0	3			
Coal . . .	3	3	29·82	Liliac grey .	Caking.
Shale band* . .	0	6			
Coal . . .	3	4½	27·70	White . .	,,
Shale band* . .	0	1			
Coal . . .	2	4	27.50	Vinaceous buff. .	,,

Bermo Seam—Kargali Colliery—contd.

Description	Thickness Ft.	Thickness In.	Ash Per cent.	Colour of ash	Nature of coal
Matti band*	0	5			
Coal	0	5	35·90	Salmon	Caking
Matti band	0	5½			
Coal	4	9	24·82	Vinaceous buff.	"
Coal with *matti* bands	0	8	27·00	Drab	"
Coal (including 1″ shaly band)	2	4	24·70	Vinaceous buff.	"
Total	28	11			

SHALE FLOOR

The proximate analysis of the average sample excluding bands marked * is :—

	Per cent.
Mositure	0·72
Ash	27·24
Volatiles	25·48
Fixed carbon	46·56
	100·00

Calorific value of the coal	5,730 calories, or 10,314 B.t.u.
Nature of the coal	Caking.
Colour of the ash	Grey.

It may be mentioned that all the individual coal bands, when tested were found to be of coking coal.

The Bermo seam was not worked in the Bokaro colliery area when it was examined. West of the Gobindpur fault, in the Gobindpur area, the seam is found cropping out in the Montiko river and in the country further west of the N.N.W.—S.S.E. fault. The seam in the former area, is about 25 feet thick dipping south to south-east at 20° and is affected by several faults. In the area west of this the dip swings from south-south-east to south-south-west, the amount of dip varying from 15° to 20°. In the Sawang colliery area a multiple intrusion of a mica-peridotite sill is noticed in the Bermo seam which appears to be not worth working. In the Pipradih area the Bermo seam lies in an area affected by many faults.

Reserves (Bermo Seam).

The reserves of coal available from the Bermo seam are given below :—

Quarriable coal from the Bermo seam, East Bokaro Coalfield

Name of area	Average thickness	Average dip	Reserves in tons				Remarks
			1 With over-burden equal to the thickness of the seam	2 With over-burden twice the thickness of the seam	3 With over-burden thrice the thickness of the seam	4 Down to specified depths	
	Ft.						
Dhori area . . .	30	15°	1,701,000	3,402,000	5,103,000	10,650,000	Down to a depth of 270 feet.
Kargali area .	40	7°	2,754,000	5,508,000	8,262,000	12,860,000	Down to a depth of 180 feet.
Bokaro area . .	30	5°	2,774,000	5,548,000	8,322,000	8,322,000	Down to a depth of 120 feet.
Gobindpur area .	25	15° to 20°	..	..	..	26,250,000	Down to a depth of 2,500 feet.
		Total	7,229,000	14,458,000	21,687,000	58,080,000	

3. KARGALI SEAM

Dhori area.

Next in importance above the Bermo seam is the Kargali seam the easternmost outcrop of which is seen in the Dhori colliery and continues westwards. In the Dhori area, the seam is split into the top and the bottom seams, the parting between the two varying from about 35 feet of shales and sandstones at the outcrops to about two feet of the same rocks at the Kargali colliery boundary to the west. Both the top and the bottom seams have been quarried to certain distances, the bottom one having been quarried near the railway line close to the Gobindpur fault (locally known as the Gobindpur-Pichhri fault) where there is hardly any scope for further quarrying. Mining has been carried out in both the seams from the outcrops by inclines driven into the seams. Depillaring has been almost complete in the top seam. To augment the output during World War II quarrying to greater depths was commenced at the outcrop of the top seam from 1944.

The dip of the Kargali seams is south-south-westerly to south-westerly at about 20° in the northern part of the colliery, swinging round to nearly west at 30° in the southern portion close to the Gobindpur-Pichhri fault.

In this area the thickness of the top seam is about 29 feet whereas the bottom one is nearly 34 feet thick. The following section of the top seam near the No. 4 incline in the Dhori colliery gave the analytical results as given below :—

Top Kargali seam—Dhori Colliery

Description	Thickness Ft.	In.	Ash per cent.	Nature of the coal
SHALE ROOF with thin lenticles of coal.				
Slickensided coal	0	11	43·90	Non-coking.
Coal	1	10	17·90	Coking.
Shaly band*	0	3		
Coal	1	10	20·60	,,
Shaly band*	0	5		
Coal	0	6	29·30	,,
Shale and *matti* band* . . .	0	1½		
Coal	2	2½	17·30	,,
Thin *matti* band*	0	½		
Coal	1	7	17·94	,,
Shaly band*	0	2		

Top Kargali seam—Dhori Colliery—contd.

Description	Thickness Ft.	Thickness In.	Ash per cent.	Nature of the coal
Coal	0	8	22·50	Coking.
Shaly band*	0	3		
Coal	0	6	19·92	,,
Shaly band*	0	2		
Coal	2	10	21·32	,,
Matti (sideritic) and stone band* . .	0	3		
Coal	3	6	13·30	,,
Matti band (lenticular)* . . .	0	10		
Bright coal	1	4	11·50	,,
Shaly band*	0	2		
Coal	0	9	19·50	,,
Shaly band*	0	2		
Coal	0	11½	13·90	,,
Shaly band*	0	2½		
Coal (including 3 bands ½″, ½″ and ¼″) .	4	2	18·20	,,
Shaly band*	0	2½		
Coal	1	1	13·50	
Shaly band*	0	3		
Coal	0	5	20·30	,,
Shaly band*	0	2½		
Shaly coal	0	9	34·80	,,
Total . .	29	6½		

SHALE FLOOR

The proximate analysis of the coal excluding all bands marked * is as follows :—

	Per cent.
Moisture	0·72
Ash	19·12
Volatiles	25·22
Fixed Carbon	54·94
	100·00

Calorific value of the coal	6,500 calories or, 11,700 B.t.u.
Nature of the coal	Caking.
Colour of ash	Vinaceous buff.

The bottom Kargali seam was sampled underground in No. 7 incline and the details of the section together with the analytical results are given below :—

Bottom Kargali seam—Dhori Colliery

Description	Thickness Ft.	Thickness In.	Ash per cent.	Colour of ash
SHALE ROOF				
Shaly coal and decomposed coal* .	6	7		
Coal	4	5	24·64	Light French grey.
Soft *matti* band* (varies from 2½ in. to 1 ft.)	0	6		
Coal	1	1½	21·64	Grey.
Shale band*	0	3½		
Coal	3	1½	22·60	Light drab grey.
Shale*	0	6		
Coal	1	7½	23·16	Ecru drab.
Shaly band*	1	0		
Coal (including ½″ shaly band) . .	5	2½	23·04	Light French grey.
Shaly band*	0	3		
Bony coal	0	8	29·98	Grey.
Coal	2	4	24·56	Grey.
Shaly band*	0	3		
Coal	3	0	20·48	Grey.
Shaly coal*	0	3		
Coal, inferior	0	8	41·00	Greyish white.
Streaky coal band*	0	4		
Coal	2	0	24·08	Greyish white.
Total .	34	1½		
CARBONACEOUS SHALE FLOOR				

The proximate analysis of the average sample excluding bands marked* is :—

	Per cent.
Moisture	0·94
Ash	23·18
Volatiles	22·30
F. Carbon	53·58
	100·00

Calorific value of the coal	6,290 calories or 11,320 B.t.u.
Nature of the coal	Caking.
Colour of the ash	Grey.

So far the Dhori Colliery authorities have worked the area north of the Gobindpur-Pichhri fault, although the leasehold of 3,750 bighas extends southwards into the trough formed by the Gobindpur-Pichhri and the Dhori-Pichhri faults. With a view to ascertaining if the Kargali, or any other seam, exists in the trough formed by the two faults, the Geological Survey was consulted in 1943 by Messrs. Anderson, Wright & Co. The author examined the area in detail in March, 1943 and suggested putting down boreholes in the rectangular area bounded by the faults. The first site selected was south of the Bermo-Dumri motor road and east of the small *nala* originating from the big tank in the colliery area. This borehole known as the Dhori borehole No. 1 (Companys' B.C.F. No. 1) was put down in 1944. The top Kargali seam was met with at 406 ft. proving a thickness of 40 ft. and the bottom at 505 ft. 8 in. having a thickness of 27 ft. 6 in. A second borehole, Dhori borehole No. 2 (Company's F.I. No. 2) was put down by the Company in 1949 about 75 ft. south-east of Borehole No. 1 and proved the top Kargali seam of 29 ft. 3 in. at 430 ft. and the bottom with a thickness of 33 ft. 5 in. at 504 ft. 10 in. The sections of the two boreholes are given in Plate VIII.

The rocks in the neighbourhood of the Dhori borehole No. 1 have a general east-south-easterly dip at an angle of 22°. It may, therefore, be assumed that provided the top Kargali seam maintains the same direction and amount of dip as those of the surface rocks and is unaffected by any, fault, it will crop out at a place about 1,000 ft. west of the borehole. Unfortunately, no sign of any coal outcrop is seen at this assumed distance or anywhere in between this place and the Borehole No. 1. The outcrop, however, may have been concealed by the soil cover. However, to locate any hidden outcrop of the top Kargali seam a borhole was put down in February, 1945 about 100 ft. east of the sand line. This borehole cut a 5 ft. seam (Amlo seam) at a depth of 36 ft. but failed to prove the Kargali seam even though the hole was taken down to a depth of 290 ft.the maximum capacity of the boring machine. Perhaps a cross fault intervened. In 1949 the company put down three other boreholes (Company's G.O. Nos. 1 and 2 and F. I. No. 1) in this area south of the Gobindpur-Pichhri fault. While the first two boraholes proved a seam 12 ft. 3 in. thick (doubtful as no core was recovered) and another 19 ft. 9 in. thick at 172 ft. 6 in. and 252 ft. 9 in. respectively, the third one proved a seam 9 ft. 6 in. thick 422 ft. 2 in. and thereafter about 30 ft. of shale after which the boring was stopped.

The company had driven inclines from their area north of the Gobind-pur-Pichhri fault to the one south of it to meet the coal seam encountered at 406 ft. in the Dhori borehole No. 1 with the ultimate object of wroking the latter area in the trough formed by the two big faults. The inclines had encountered a crushed zone in the Gobindpur-Pichhri fault alignment where some faulted and heavily slickensided coal seams were also met with. These inclines were driven to certain distances but were ultimately abandoned due to the crushed nature of the rock they had to pass through. Thus the area south of the Gobindpur-Pichhri fault was left unworked till 1951 when the survey was completed in the Bokaro coalfield.

Kargali and Bokaro areas

The Kargali area lies west of the Dhori colliery. In the Kargali area and west of it the Kargali seam occurs as one thick seam ; the parting between the top and bottom seams, as met with in the Dhori area, decreases from 2 ft. 6 in. in the eastern portion to 1 ft. 3 in. in the western end so that at the easternmost end of the Kargali colliery the parting is not more than 1 ft. 3 in. The coal seam (two seams forming one seam) dips S. 10°W. at low angles varying from 5° to 6°. The thickness of the seam varies from nearly 69 ft. to about 72 ft. of the two adjacent collieries, Kargali and Bokaro, the latter is situated contiguous west of the former and previously belonged to the Great Indian Peninsular Railway. The Bokaro colliery belonged jointly to the East Indian and the Bengal Nagpur Railways. They were started in the years 1917 and 1915 respectively and have come under the control and management of the Indian Government Railways from 1925 and 1924 respectively. In both the collieries the Kargali seam is worked by quarrying although some years back it was also worked underground through a pair of vertical shafts approximately 450 ft. deep, sunk to the floor of the seam (Plate II, fig. 1) and through an incline. Galleries have been driven in both the top and the bottom sections. Practically the whole of the mine is standing in pillars.

At Kargali the coal seam is practically unaffected by faults excepting in the western portion where some minor faults were noticed. The area is traversed by three dykes, aligned about east-west, of which the middle one is of mica-peridotite (mica-lamprophyre). The other two dykes are of a fine-grained acidic type of rock, the colour varying from whitish and light greyish to light brownish. In hand specimens it looks like an aplitic rock, but ovservations in different parts of the field have led to the conclusion that it is an altered and silicified mica-peridotite especially as it often occurs in continuation of the strike of, and sometimes in between two portions, of a mica-peridotite dyke. At Kargali proper, the rocks do not contain much mica and there is nothing to indicate that they belong to the mica-peridotite type but a close observation of similar rocks in the Jarangdih colliery, west of Bokaro, has revealed a gradation from the mica-peridotite to an acid type of rock containing a fair quantity of mica of the original mica-peridotite still intact. After careful observation, it appears convincing that the acid type of rock is nothing but altered and silicified mica-peridotite.

The following are the sections of the Kargali seam sampled in quarries Nos. 3 (at the eastern end) and 1 (at the western end) with the analyses :—

Kargali Seam—Quarry No. 3, Kargali Colliery

Description	Thickness		Analysis				Calorific Value		Colour of ash	Nature of Coal
	Ft.	In.	Moisture %	Volatiles %	F. Carbon %	Ash %	Calories	B.t.u.		
SHALE ROOF										
Slickensided coal . .	0	10	0·94	23·90	50·86	24·30	6,010	10,815	Ecru drab	Coking
Shale band* . . .	0	2½								
Coal (including 3 bands ½″, ½″, and ¼″).	6	7	0·92	26·34	54·64	18·10	6,455	11,620	,,	,,
Shale band* . . .	0	1								
Coal	0	6	1·06	26·00	56·14	16·80	6,630	11,935	,,	,,
*Matti band** . . .	0	4								
Coal (including one 2″ shaly band).	2	6	0·88	29·50	58·02	11·60	6,945	12,500	,,	,,
Shale and bony band* .	0	4								
Coal (including 2″ shaly band).	1	6	0·88	27·20	56·72	15·20	6,720	12,100	Vinaceous buff	,,
Shale band* . . .	0	4½								
Coal . . .	0	6	0·96	28·56	58·28	12·20	6,980	12,650	Pearl grey	,,

Shale band* . . .	0	4								
Coal	0	3	0·66	22·36	45·78	31·20	5,335	9,600	Cream buff	,,
Shaly band* . . .	0	2½								
Coal	0	3	0·96	23·58	61·10	14·36	7,005	12,610	Vinaceous pink	,,
*Matti band** . . .	0	2								
Coal (including ½″ shaly band).	1	7	1·02	27·84	57·68	13·46	6,875	12,375	Vinaceous cinnamon	,,
Shaly coal band* . .	0	2								
Coal	0	3	0·76	21·96	43·28	34·00	5,140	9,250	White	,,
Shaly band* . . .	0	3								
Coal	3	1	0·74	25·52	57·24	16·50	6,655	11,975	Pinkish buff	,,
Shaly coal* . . .	0	5								
Coal	1	9	0·70	23·48	50·82	25·00	5,960	10,730	Vinaceous buff	,,
*Matti band** . . .	0	1								
Coal	1	3	0·84	22·32	59·14	17·70	6,770	12,180	Broceoli brown	,,
Shaly band* . . .	0	4½								
Coal (including 1½″ shaly band).	3	0	0·88	26·96	56·16	16·00	6,660	11,990	Ecru drab	,,
Shale*	0	2								
Coal . .	1	5½	1·46	24·04	48·00	26·50	5,620	10,120	Salmon buff	,,

Kargali Seam—Quarry No. 3, Kargali Colliery—contd.

Description	Thickness		Analysis				Calorific Value		Colour of ash	Nature of Coal
	Ft.	In.	Moisture %	Volatiles %	Fixed Carbon %	Ash %	Calories	B.t.u		
Middle band: Slickensided. Shaly coal.	0	10	1·44	12·76	15·00	70·80	1,815	3,265	Vinaceuos pink	Non-caking
Middle band: Coal, bright Shale band*	0	7	1·34	26·76	54·40	17·50	6,540	11,770	Vinaceous buff	Caking.
Coal (including one 1″ shaly band and ½″ *matti* band).	4	9	1·26	24·24	53·50	21·00	6,350	11,430	,,	,,
Matti band* . . .	0	1								
Coal	1	2	1·10	24·46	55·94	18·50	6,520	11,740	Pinkish buff	,,
Matti band* . . .	0	2½								
Coal	2	0	1·08	23·08	54·64	21·20	6,360	11,450	Ecru drab	,,
Shale band* . . .	0	5								
Coal	0	11	1·08	24·12	55·00	19.80	6,405	11,530	Cream	,,
Matti band* . . .	0	2								

Coal	1	2	1·12	23·64	52·22	23·02	6,135	11,040	Ecru drab	,,
Shale band* . . .	0	9½								
Coal	2	10½	1·20	24·18	52·64	21·98	6,185	11,130	Salmon buff	,,
Matti band* . . .	0	1								
Coal	2	9	1·28	24·02	57·70	17·00	6,720	12,100	Vinaceous buff	,,
Shaly band* . . .	0	2½								
Coal	2	2	1·12	22·94	54·34	21·60	3,695	11,465	Vinaceous pink	,,
Matti band* . . .	6	6								
Coal (including 1″ shaly band).	1	10	1·12	23·96	44·82	30·10	5,350	9,630	Ecru drab	,,
Shaly band* . . .	0	3								
Coal . .	2	0	1·04	23·22	52·44	23·30	6,110	11,000	Salmon buff	,,
Shale band* . . .	0	3								
Coal (including one ½″ shaly band).	7	4	1·14	25·06	54·10	19·70	6,335	11,500	Ecru drab	,,
SANDSTONE FLOOR										
Total	68	8½								

*Proximate analysis of the average sample excluding bands marked * is as follows :—

	Per cent.
Moisture	1·08
Volatile matter less moisture	24·92
Fixed Carbon	54·08
Ash	19·92
	100·00

Calorific value of the coal	6,455 calories or 11,619 B.t.u.
Nature of the coal	Caking.
Colour of the ash	Vinaceous.

Kargali Seam—Quarry No. 1, Kargali Colliery

Description	Thickness Ft.	Thickness In.	Analysis: Moisture %	Analysis: Volatiles %	Analysis: F. Carbon %	Analysis: Ash %	Calorific Value: Calories	Calorific Value: B.t.u.	Colour of ash	Nature of Coal
SHALE ROOF										
Coal, slickensided . .	0	10	1·23	26·90	56·46	15·40	6,670	12,005	White	Caking.
Bony coal* . . .	0	6								
Coal	2	0	1·30	28·02	53·76	16·92	6,490	11,680	Ecru drab	,,
Coal with shaly bands .	1	3	1·12	26·98	48·44	23·46	5,880	10,585	Grey	,,
Bright coal . . .	4	2	1·28	29·64	53·98	15·10	6,600	11,880	Ecru drab	,,
Bright coal . . .	3	3	1·14	28·36	54·30	16·20	6,585	11,850	White	,,
Coal	1	6	1·40	27·96	59·78	10·86	7,100	12,780	Grey	,,
Coal	2	0	0·74	31·02	52·94	15·30	6,495	11,695	White	,,
Motti band* . . .	0	5								
Bright coal (including two shale band ½″&1½″ thick).	4	0	0·76	30·12	54·26	14·86	6,595	11,870	White	,,
Coal (including 3 band , 1″, 2″ & 2″ thick).	2	8	0·56	27·32	48·90	23·22	5,940	10,695	French grey	,,
Shale band* . . .	0	2								

Kargali Seam—Quarry No. 1, Kargali Colliery—contd.

Description	Thickness Ft.	Thickness In.	Analysis: Moisture %	Analysis: Volatiles %	Analysis: F. Carbon %	Analysis: Ash %	Calorific Value: Calories	Calorific Value: B.t.u.	Colour of ash	Nature of Coal
Coal (including one 2½" band).	3	3	0·76	26·38	49·16	23·70	5,940	10,695	Ecru drab	Caking.
Coal (including one 3" shale band).	4	10	0·76	26·56	51·18	21·50	6,275	11,300	Grey	,,
Coal	2	6	0·58	28·90	53·02	17·50	6,465	11,635	Pearl grey	,,
Bony Coal* . . .	0	4								
Shale band* . . .	0	3								
Coal	2	1	0·70	24·34	55·26	19·70	6,460	11,650	Plumbeous	,,
MIDDLE BAND* (with 4" coal at places 3" from top).	1	3								
Coal (including 2" band)	3	2	0·80	26·92	56·88	15·40	6,720	12,100	Ecru drab	,,
Shale band* . . .	0	3½								
Coal	3	4	0·62	24·44	55·54	19·40	6,540	11,775	White	,,
Matti band* (soft) . .	0	6								
Coal	3	6½	0·74	25·04	57·22	17·00	6,665	12,000	Light ecru	,,

Matti band* (soft) . .	0	2								
Coal	1	4	0·66	25·50	55·84	18·00	6,610	11,895	Cream buff	,,
Bony coal . . .	1	0	0·54	21·82	39·74	37·90	4,790	8,625	Grey	,,
Coal	6	1	0·80	24·24	54·26	20·70	6,295	11,330	White	,,
Matti band* (soft) . .	0	3								
Coal	4	0	0·88	23·86	51·34	23·92	6,045	10,885	Whitish grey	,,
Matti band* . . .	0	3								
Coal	6	6	0·76	25·38	54·78	19·08	6,470	11,654	Ecru drab	
Coal	4	0	0·74	23·58	48·28	27·40	5,750	10,350	Vinaceous pink	,,
SANDSTONE FLOOR.										
Total .	71	8								

The proximate analysis of the average sample excluding all bands marked * is given below :—

	Per cent.
Moisture	0·82
Volatiles	25·56
Fixed Carbon	54·24
Ash	19·38
	100·00

Calorific value of the Coal	6,490 Calories or 11,682 B. t. u.
Nature of the Coal	Caking.
Colour of the ash	Ecru drab.

Until the year 1944, the removal of overburden over the coal seam was restricted to the proportion of 1 : 1. This used to be done by the ordinary methods, namely by haulage and manual labour. During World War II, due to the acute shortage of coal, a greater thickness of overburden, in the ratio of 2 : 1 with the coal, was decided to be removed, thereby introducing the open cast mining with modern earth moving machinery. Mechanised outcrop coal mining was first introduced in India in 1944 in the Kargali and Bokaro colliery areas. Excavating plants varying in sizes from half to 4 cubic yard capacity fitted with shovel equipment were used. All excavators over two cubic yard capacity were electrically driven, while those with smaller capacities were powered by Diesel engines. The method of excavation was the "bench" system. Benches varied in depth according to the size of the excavators ; but as the majority of the excavators were of the four cubic yard capacity, the "benches" averaged 30 ft. in depth. A four cubic yard machine was capable of loading 45,000 cubic yards (approximately) of rock per month into Euclid vehicles. The organisation responsible for the removal of the overburden is the Indian Mining and Construction Co., Ltd.

The rock had to be drilled and blasted. Of the four benches at Kargali, three were blasted in the ratio 3 : 1 (*i.e.*, 3 cubic yards of overburden to 1 lb. of open cast gelignite), while the 4th, when there was hard sandstone, had to be blasted in the ratio 2 : 1. All the drilling was done by T. 29 Percussion Drills. These machines were capable of drilling holes 10 in. in diameter at 8 ft. per hour. It took two drilling machines to keep one 4 cubic yard excavator with dig for 16 hours The maximum permissible charge of explosives was 1,250 lbs. until the introduction of delayed action detonators when it was raised to 2,500 lbs. The average depth of overburden at Kargali was 100 ft. In all 10 excavators were working and an average of 40 Euclid Trucks transported the rocks.

Continuing westwards form the Kargali area the Kargali seam is found in the Bokaro area, the largest colliery in the field so far as production is concerned. All the production is from the Kargali seam by quarrying only, the number of quarries having increased to six by 1951. Previously, besides quarrying, underground mining was done ; but this has since been discontinued. Two shafts were previously sunk and fitted, but now they are out of use. In the Bokaro No. 6 quarry, when the Indian Mining and Construction Company had been removing the overburden, a normal fault starting in the coal itself has been noticed after the removal of the overburden. This fault is heading E.N.E. at 50°, and has an increasing throw from 0 ft. to 60 ft. up to the point to which the overburden had been removed by 1951. The fault, better known as the 'Scissors fault', is to be seen in Pl. III Fig. 3. West of the fault, from where also the overburden had been removed, the coal has a gentle rolling surface with a general rise (instead of dip) towards the Dhori-Jarangdih road. The advantage resulting form this fault is that the coal occurs under a mantle of overburden much less thick than would normally have been. It appears therefore that in this area due to the gentle rolling of the seam the whole of the coal could be quarried definitely up to the Dhori-Jarangdih motor road, and possibly up to the Chandrapura-Jarangdih-Ranchi Road railway line. The rolling of the seam appears to be due to compression and ultimate faulting in the coal.

The dip of the Kargali seam in Bokaro Colliery is generally in a south-southeasterly direction at 5° to 6° and sometimes even less, changing to east-south-east at 20° near the Gobindpur fault which has cut off the seam throwing it down several hundred feet to the south. This fault forms the southern boundary of the Bokaro quarry No. 5, where it is clearly exposed, heading southwards at 35°. In the area south of the Gobindpur fault it is possible that the Kargali seam exists at great depths below Jaridih (23°46′ : 85°56½′). This has yet to be proved by putting down boreholes.

Mica-peridotite dykes are found in quarries Nos. 2, 4 and 5 (Pl. IV Fig. 1) forming *jhama* and coke at the contact with coal but the damage caused is believed to be slight. In this area the Kargali seam has attained a thickness of nearly 100 ft. increasing from 75 ft. in quarry No. 3 adjacent to the Kargali area to 98 ft. 11 in. as found in a section sampled in quarry No. 6. The details of the section met within the last named quarry with the analytical results are given below :—

Kargali Seam—Bokaro Quarry No. 6.

Description	Thickness Ft. In.	Analysis: Moisture %	Analysis: Volatiles %	Analysis: F. Carbon %	Analysis: Ash %	Calorific Value: Calories	Calorific Value: B.t.u.	Colour of Ash	Nature of Coal
SHALE ROOF (contains thin lenticles of coal)									
Coal	1 8	0·98	26·38	56·32	16·32	6,690	12,040	Ecru drab	Caking
Shaly band* . . .	0 2								
Bony coal and coal . .	2 11½	1·10	26·08	55·90	16·92	6,590	11,860	,,	,,
Shaly band* . . .	0 3½								
Coal	0 8	1·10	28·86	56·80	13·24	6,860	12,345	,,	,,
Shaly band* . . .	0 2								
Coal	0 7½	1·08	27·60	52·32	19·00	6,360	11,450	,,	,,
Shaly band* . . .	0 2								
Coal	0 9	0·82	29·96	56·54	12.68	6,895	12,410	,,	,,
Shaly band* . . .	0 2								
Coal	2 7	0·72	31·28	59·14	8·86	7,220	13,900	,,	,,
Matti band with coal* . .	0 6 (average)								
Coal	0 10½	0·90	30·14	58·66	10·30	7,117	12,812	White	,,
Shaly band* . .	0 3								

Coal	1	1	0·74	29·34	54·12	15·88	6,710	12,080	Light ecru drab	,,
Shaly band* . . .	9	2								
Coal, bright . . .	1	1	0·82	32·42	58·26	8·50	7,212	12,983	Pinkish buff	,,
Shaly band* . . .	0	3½								
Coal	5	3	0·66	27·84	59·70	11·80	7,066	12,720	Vinaceous pink	,,
Matti band* . .	0	7								
Coal	0	11	0·99	30·00	59·22	9·90	7,127	12-830	White	,,
Shale band* . . .	0	1½								
Coal	0	7	0·94	28·64	57·02	13.50	6,922	12,460	,,	,,
Shale band* . . .	0	2								
Coal (including ½′ shaly band)	3	0	0·92	28·10	57·03	13·90	6,910	12,436	Light ecru drab	,,
Shaly band* . . .	0	3								
Coal	0	10	0·92	27·60	55·08	16·50	6,700	12,060	White	,,
Shaly band* . . .	0	2								
Coal	0	1½	0·90	29·14	59·46	16·50	7,111	12,800	,,	,,
Shaly band* . . .	0	3								
Coal	0	5½	0·92	26·88	56·20	16·00	6,711	12,080	Ecru drab	,,
Shaly band* . . .	0	2								
Coal	0	6	0·76	27·34	54·44	17·46	6,567	11,820	White	,,
Shaly Band . . .	0	3								

Kargali Seam—Bokaro Quarry No. 6—contd.

Description	Thickness		Analysis				Calorific Value		Colour of Ash	Nature of Coal
	Ft.	In.	Moisture %	Volatiles %	F. Carbon %	Ash %	Calories	B.t.u.		
Coal (with 1/8″ *matti* band, also 1/4″ *matti* band at places).	5	8	0·86	26·84	55·50	16·80	6,711	12,080	White	Caking
Shaly band* . . .	0	2½								
Coal	0	5½	0·84	25·52	62·94	10·70	7,095	12,770	,,	,,
Shaly band* . . .	0	3								
Coal	0	10½	0·84	26·66	58·36	14·14	6,876	12,380	,,	,,
Matti band* . . .	0	7½								
Coal	1	10½	0·96	29·18	59·46	17·40	6,616	11,810	Pearl grey	,,
Shaly band* . . .	0	3								
Coal	0	3½	0·90	24·00	47.40	27·70	5,693	10,248	,,	,,
Shaly band* . . .	0	3								
Coal (with ½″ shaly band)	2	9½	0·92	28·38	59.00	11·70	6,967	12,540	Light ecru drab	,,
Matti & Shaly band* . .	0	5								
Coal . . .	0	5	0.92	27·34	55·64	16·10	6,777	12,200	White	,,
Shaly band*	0	4								

Coal and bony coal . .	3	2½	1·24	26·00	58·10	14.66	6,833	12,300	,,	,,
Shale*	5	9½								
Coal (including ½″ shaly band)	2	1	1·34	25·82	54·84	18·00	6,489	11,680	Light vinaceous buff.	,,
Shale*	0	7½								
Coal (including an impersistent *matti* band 0-10″ thick).	2	8	1·18	27·38	57·94	13·50	6,878	12,380	Ecru drab	,,
Shale band* . . .	5	2½								
Coal	1	0	0·88	26·20	49-92	23·00	5,933	10,680	White	,,
Shale band* . . .	0	3½								
Coal (containing at places lenticles of *matti*)	5	2	0·92	26·84	57.94	14·30	6,783	12,210	,,	,,
Matti band* . . .	0	5								
Coal (with ½″ shaly band) .	2	1	0·86	25·36	60·00	13·78	6,868	12,362	Ecru drab	,,
Shale*	0	2½								
Coal	0	3	0·78	25·84	52·36	21·02	6,239	11,230	White	,,
Shaly band* . . .	0	4								
Coal (including ¼″ to 1″ shaly bands).	5	10	1·18	25·26	60·76	12·80	6,928	12,470	Vinaceous buff	,,
Motti band* lenticular, impersistent (varying).	0	0 to 5	(varying)							

Kargali Seam—Bokaro Quarry No. 6—concld.

Description.	Thickness Ft.	Thickness In.	Analysis: Moisture %	Analysis: Volatiles %	Analysis: F. Carbon %	Analysis: Ash %	Calorific Value: Calories	Calorific Value: B.t.u.	Colour of Ash	Nature of Coal
Coal (containing 2 *matti* bands max. 3″ & 5″ thick).	10	3	1·14	25·02	56·14	17·70	6,564	11,816	Vinaceous buff	Caking.
Matti band* . . .	0	5								
Coal	2	0	1·00	25·68	51·30	22·02	5,950	10,710	Pinkish buff	,,
Shaly band* . . .	0	2								
Coal	0	7½	0.62	26·28	47·10	26.00	5,783	10,410	Pinkish buff	,,
Shaly band* . . .	0	2								
Coal (contains 2 shaly bands 1″ & ½″ thick).	2	5½	0·82	24·08	54·73	20·37	6,278	11,300	Pearl grey	,,
Shaly coal* . . .	0	6								
Coal (with 1″ shale band) .	1	7	0·88	28·16	55·06	17·90	6,528	11,750	Pinkish buff	,,
Shaly band* . . .	0	3								
Coal	1	11	0·98	28·68	57·84	12·50	6,950	12,510	White	,,
Matti band* . . .	0	3 (average)								

Coal	5	7	0·98	26·42	59·40	13·20	6,928	12,470	Pinkish buff
Coal, Shaly . . .	1	4	0.88	26·36	53·34	19·24	6,361	11,420	White
Total	98	11							

SHALE FLOOR

The proximate analysis of the average sample excluding all bands marked* is as follow :—

	per cent.
Moisture	0.96
Volatiles	26·76
Ash	15·23
Fixed Carbon	57·05
	100·00
Calorific value of the Coal	6,815 caloriess or 12,267 B.t.u.
Nature of the coal	Caking.
Colour of the Ash	Ecru Drab.

Although sampling of the Kargali seam has been done in no other quarry of the Bokaro colliery, it is gathered that the thickness of the seam has increased further by a few feet in quarry No. 1, thus exceeding 100 ft., a maximum for this seam in the Bokaro coalfield. Here the seam is cut off by a N. W.—S.E. fault forming its south-western boundary. This fault has shifted the seam southwards exposing it in the Godo *nala*, on either side of which quarries Nos. 2 and 4 are situated. The outcrop of the Kargali seam has been very badly burnt in a westerly direction, so much so that west of No. 4 quarry only "burnt outcrops together with clinker *jhama* and burnt rocks are found in abundance. The burnt rocks extend westwards up to a mile and a quarter south-east of Gobindpur (23° 48′ ; 85° 53′).

It has been found that practically over the whole of the Bokaro colliery area the Kargali seam exists at a quarriable depth and it may be possible to extend the quarries right up to the existing Gomoh-Barkakhana railway line which passes through the property. It may even be presumed that if a new alignment could be found for the railway line, the quarries could extend much further to the south. There are no underground workings at Bokaro at present. Two shafts were previously sunk and fitted, but now they are out of use.

The annual output of the Kargali and Bokaro collieries is given below :—

Output of coal from the Kargali and Bokaro collieries

Year	Kargali Colliery (Tons)	Bokaro Colliery (Tons)
1915-1916	..	62,754
1916-1917	..	2,13,382
1917-1918	1,05,814	2,90,733
1918-1919	1,92,223	3,52,216
1919-1920	2,88,505	4,58,342
1920-1921	4,26,706	4,88,825

Output of coal from the Kargali and Bokaro collieries—contd.

Year	Kargali Colliery (Tons)	Bokaro Colliery (Tons)
1921-1922	4,26,706	4,97,593
1922-1923	3,82,036	5,66,916
1923-1924	3,84,563	5,35,852
1924-1925	5,28,845	7,11,332
1925-1926	6,05,438	7,21,374
1926-1927	6,78,513	6,52,066
1927-1928	8,85,686	9,89,727
1928-1929	7,62,451	9,22,175
1929-1930	9,14,059	9,69,984
1930-1931	8,17,582	8,52,472
1931-1932	6,36,429	6,41,124
1932-1933	4,14,716	4,85,592
1933-1934	4,87,091	5,51,650
1934-1935	4,36,920	6,72,416
1935-1936	4,27,087	6,11,500
1936-1937	5,76,581	7,69,848
1937-1938	8,52,790	10,80,739
1938-1939	6,61,352	10,30,621
1939-1940	7,02,912	10,52,436
1940-1941	6,31,173	10,04,533
1941-1942	7,93,594	10,93,351
1942-1943	5,48,006	9,51,235
1943-1944	4,94,349	8,42,120
1944-1945	5,03,242	8,56,312
1945-1946	7,47,018	11,59,571
1946-1947	5,57,368	16,47,612
1947-1948	6,93,523	12,27,210
1948-1949	6,06,518	10,90,217
1949-1950	6,07,827	11,99,495
1950-1951	5,28,837	10,30,282

The approximate numbers of labour employed in 1946 in the Kargal and Bokaro collieries were 15,000 and 7,575 respectively.

Gumia Section

The area to the west of the Bokaro colliery on the southern side of the Gobindpur fault, lying between Jarangdih (23° 46′ : 85° 54½′) and the Lugu Hill, is known as the Gumia section. This area was examined in detail and a considerable portion of it was mapped on a scale of 16″=1 mile in 1916 and 1917 by Dr. Fermor. Several boreholes also were put down under his instructions and guidance. Two reports, one dated 14th August, 1916 and the other, 25th January, 1918, were submitted by him and appear as Appendix I in this Memoir. He detected several faults and succeeded in working out the complete sequence of coal seams in that area. According to his numbering from the base (the lowest seam being No. 1), the Kargali seam becomes the No. 13 seam. The Barakar rocks in this area form a syncline of which a large portion of the southern limb has been faulted out, as for instance, at Jarangdih. Besides the Gobindpur fault Sir Lewis Fermor recognised two other major faults, namely, the Borea fault and the southernmost Kathhara fault. These three major faults were also recognised by the author. The Borea and the Kathhara faults, which have a general east-west trend, meet together east of Asnapanitoli (23°46′ : 85°54′). It has been found that the downthrow is to the south. From field evidence it is clear that both the Borea and the Kathhara faults are heading to the north. The occurrence of the Kargali seam in the trough formed by the Gobindpur and the Borea faults had been proved by Dr. Fermor. Whereas outcrops of the Kargali seam were noted at Palihari-Gurudih (Pipradih area), Sawang and Gobindpur, its existence was proved by his borehole No. XV (D.B.H. 3B) at Jarangdih (Pl. IX), which cut through 126 ft. 2 in. thickness of the Kargali seam at a depth of 1,414 ft. Another borehole at Jarangdih (No. XX) proved the Kargali seam to be 147 ft. 6 in. in thickness at a depth of 1,110 ft. Two other borings, namely, No. VIII at Sawang (Pl. IX) and No. XI at Gobindpur, proved the Kargali seam to be much thinner than at Jarangdih, and affected by mica-peridotite intrusions. Dr. Fermor divided the area between the Gobindpur and the Borea faults into five blocks for working them with advantage. Further, although the Kargali seam was also expected to occur in the area bounded by the Borea and the Kathhara faults, its existence was proved as late as 1945 by borings put down by Bokaro and Ramgar Ltd. under instructions of the author. The details of the Kathhara area will be given later on.

Jarangdih Area

The Jarangdih colliery area which is situated west of the Bokaro colliery at the junction of the Konar and the Damodar rivers previously belonged jointly to the Bombay, Baroda and Central India and the Madras and southern Mahratta Railways and has later come under the management of the Indian State Railways. The Kargali seam, an outcrop of which occurs north of the Gobindpur fault, exists at a depth of over 900 ft. south of the same fault. The outcrop of the seam is

found between the Gobindpur and another W.N.W.—E.S.E. fault and is affected by some minor faults at its middle portion. The seam was previously quarried at the outcrop, but the quarry was not very extensive as the length of the outcrop was short and the dip of the seam was rather steep at 40° to 45°. The quarry now stands abandoned. While coal was being extracted from the quarry, the Kargali seam south of the Gobindpur fault had been mined by sinking a pair of shafts 930 ft. deep. The total thickness of the seam as met with in the shaft is over 100 ft. out of which only a small section was worked. A minor fault affecting the coal was noted in the shafts. The dip of the seam is almost north at 25°. The development of underground workings was being carried out but very great difficulties were being experienced due to the presence of large quantities of methane gas. Actually a fire-damp explosion occurred in the shaft workings on the 7th August, 1930, and the mine had to be flooded with water to a height of 350 ft. The pits were de-watered and the mine re-started by the middle of 1931. A steam driven Walker fan with capacity of 500,000 c.ft./minute was installed for facility of work. But owing to the trade slump from 1933 onwards, costs of working the colliery proved to be prohibitive and the mine was finally abandoned in the middle of the year 1936.

Gobindpur Area

The area westwards next to the Jarangdih Colliery where the Kargali seam crops out is Gobindpur where the seam remains to be developed. From earlier reports it appears that the coal in the eastern part of the area is seriously coked near the surface. Dr. Fermor's borehole No. VII on the western part of the property proved only two feet of *Jhama*, whilst his borehole No. VI on the eastern part showed the seam to be entirely coked. Bokaro and Ramgur Ltd. carried out prospecting operations here. The Company had put down, about 100 yards west of the Montiko river, a trial shaft where primitive methods of mining were adopted (Pl. VI, fig. 1). The Kargali seam was met within the shaft at a depth of 23 feet from the surface. The dip of the seam is in a south-south-easterly direction, the amount of dip being in the neighbourhood of 20°. The thickness of the seam, as met with in the trial shaft, is 39 ft. 7 in. in which two mica-peridotite intrusions are noted. Sampling of the natural section was very difficult as the work had to be done in a shaft with much percolation of water and in the absence of proper lighting facilities ; consequently foot by foot samples were taken. The following are the details of the samples together with the analytical results :—

Kargali seam—Gobindpur Trial Shaft.

Thickness		Description	Ash content	Colour of ash
		SHALE ROOF	%	
Ft.	In			
1	0	*Jhama* mostly . . .	18·35	Whitish grey
1	0	Coal with greasy lustre .	13·35	Grey
1	0	Coal with greasy lustre .	11·30	Light ecru drab
1	0	Coal with dull lustre .	14·60	Grey
1	2	Mica-peridotite sill*		

Kargali seam—Gobindpur Trial Shaft—contd.

Thickness Ft.	In.	Description	Ash content %	Colour of ash
1	0	Coal, pitch black with dull lustre.	16·90	Grey
1	0	Coal with dull lustre .	19·25	Ecru drab
1	0	Coal, mostly durain .	13·20	Grey
1	0	Coal, mostly durain .	13·85	Grey
1	0	Coal with bright lustre .	16·45	Grey
1	0	Coal with dirt bands .	14·60	Light ecru drab
1	0	Coal with thin shale bands	15·65	Light ecru drab
1	0	Coal with thin shale bands	16·80	Grey
1	0	Coal, mostly durain . .	15·20	Grey
1	0	Coal with pitch-black lustre	12·00	White
1	0	Coal with shale bands .	20·75	White
1	0	Bright and dull bony coal	18·30	Grey
1	0	Bright and dull bony coal	18·85	Greyish white
1	0	Coal, mostly durain . .	15·45	Grey
1	0	Coal, mostly durain . .	14·35	Greyish white
1	0	Coal with dull lustre with streaks of vitrain.	20·85	Grey
1	0	Coal	16·20	Grey
1	0	Slightly *jhama* . .	13·35	Grey
1	0	*Jhama* ?	14·25	Whitish grey
1	0	Coal with dull lustre .	17·60	Grey
1	0	Coal with dull lustre .	15·35	Lavender grey
1	0	Coal with *jhama* lustre .	22·80	Lavender grey
1	5	Sill of mica-peridotite.*		
1	0	Coal changing to *jhama* .	15·20	Grey
1	0	Coal changing to *jhama* .	22·00	Chocolate
1	0	Coal with shale bands .	26·60	Ecru drab
1	0	Coal with pitch-black lustre	16·80	Ecru drab
1	0	Bright coal with shale bands	19 70	Grey
1	0	Bony coal with shale bands	32·20	Whitish grey
1	0	Bright coal with shale bands	16·15	Grey
1	0	Coal with pitch-black lustre	10·55	Grey
1	0	Coal with pitch-black lustre	18·30	Ecru drab
1	0	Coal, bright black . .	22·35	Cream buff
1	0	Shaly coal	26·25	Grey
39	7	Total		

CARBONACEOUS SHALE FLOOR

The proximate analysis of the seam excluding bands marked * is :—

	Per cent.
Moisture	1·30
Ash	17·60
Volatiles	28·10
F. Carbon	53·00
	100·00

Calorific value of the coal	6,734 calories or 12,121 B.t.u.
Nature of the coal	Caking : yields very good light spongy, hard coke.
Colour of the ash	White.

The outcrop of the Kargali seam was traced, after a careful search, in the Montiko river where it was obscured by a cover of loose sands. Here also the seam was affected by mica-peridotite sills.

To prove the extent as also the condition of the seam on the dip side, Dr. Fermor previously had his borehole No. XI drilled about half a mile south of the site of the Gobindpur Trial shaft in the area south of the Montiko river but north of the Konar. The Kargali seam was touched at a depth of 1,158 ft. from the surface. The section of the seam from the top is :—

	Ft.	In.
Coal	21	0
Jhama	0	4
Mica-peridotite	0	4
Coal	26	10
Total	48	6

A deep borehole on the eastern part would be necessary to prove the condition of the seam here whether the coal has developed stronger coking properties or has even ceased to be caking on the dip side. In any case the total area underlain by the Kargali seam, even leaving aside the area east of the fault crossing the Montiko river about ¾ mile from its junction with the Konar, appears to be considerable and workable, although the working conditions may not be as favourable as in some other areas.

Sawang Colliery Area

West of Gobindpur the Kargali seam crops out in the Sawang Colliery area, the next area worked west of the Jarangdih Colliery, also managed by the Indian State Railways. The Sawang Colliery was worked from the year 1923 under the control of the East Indian and Bengal Nagpur Railways jointly and was taken over by the present owners in 1925. The Kargali seam is worked here by quarrying at the outcrop as also by underground mining through inclines where the bottom 6½ ft. section is being worked. With the formation of a few panels

depillaring operations, with a longwall face about 500 to 600 ft. long, are being conducted, the depillared area being completely stowed with sand by hydraulic method. The seam has decreased in thickness towards the west from Jarangdih and is a little over 40 ft. at Sawang. The dip of the coal seam is in a general south-south-westerly direction, the amount varying from 22° to 26°. A mica-peridotite dyke inclined at an angle is found traversing the seam in the western part of the colliery area. About the middle portion of the outcrop in the property and west of the inclines there is a burnt ground where the coal outcrop has partly been reduced to clinker and ash (Pl. V, fig. 1), the overlying rocks also being burnt to a light brownish material. At the western end of the colliery there is a double outcrop of the Kargali seam : the repetition has been brought about due to faulting.

In the underground workings of this colliery sand-stowing is done, the sand being obtained from the Konar river. The thickness of the sand in the river, although not proved by any boreholes, appears to be not less than 20 ft. at the place, north-east of the boiler house, from where the sand is usually taken out.

The Kargali seam was sampled in quarry No. 4, where the seam dips south-west to south-south-west at 30°. The section sampled, which proved to be 43 ft. 9½ in. thick, is as follows :

Kargali seam—Sawang Colliery, Quarry No. 4.

Thickness Ft.	In.	Description	Ash content %	Colour of ash
		SHALE ROOF		
0	5½	Coal	16·98	Ecru drab.
0	½	Shale sand*		
0	5½	Coal	21·10	White.
0	1	Shaly coal band*		
2	2	Coal	15·74	Ecru drab.
0	1	Soft *matti* band*		
1	5	Coal	28·02	White.
0	1	Shale*		
1	2	Coal	15·52	Light vinaceous cinnamon.
0	3½	*Matti* and shaly band*		
0	11	Coal	14·28	Vinaceous.
0	2	*Matti* and shaly band*		
0	10	Coal	16·74	Light vinaceous buff.
0	3½	Shale and shaly band*		
1	7	Coal	11·82	Ecru drab.
0	3	Soft *matti* band*		

Kargali seam—Sawang Colliery, Quarry No. 4—contd.

Thickness Ft.	In.	Description	Ash content %	Colour of ash
0	4	Coal including 1″ shaly coal	19·22	Light ecru drab.
0	2	*Matti* band*		
4	0	Coal	15·18	Ecru drab.
0	1½	*Matti* band*		
0	7½	Coal	12·04	Liliac grey.
0	4	*Matti* band* . . .	Prominent band.	
0	11½	Coal . . .	19·64	Ecru drab.
0	1½	Shaly coal band*		
1	8½	Coal .	22·56	Olive grey.
0	½	*Matti* band*		
1	11	Coal .	18·02	French grey.
0	3	*Matti* and shale band*		
0	7½	Coal	14·58	French grey.
0	3	Shaly coal*		
2	6	Coal including 1½″ shaly coal and ½″ *matti* band.	20·40	Liliac grey
0	4½	*Matt* & shaly coal band*		
3	5	Coal including two 2″ shaly coal bands.	17·60	French grey.
0	4½	*Matti* and shaly band*		
3	11	Coal including 2″ shaly coal and ½″ *matti*.	22·32	Heliotrope purple.
0	4½	*Matti* & shale band*		
2	6½	Coal including two 2″ shaly coal bands.	23·46	Ecru drab.
0	2	*Matti* band*		
1	6	Coal	18·98	Ecru drab.
0	3½	Shale and shaly coal*		
1	4½	Coal	24·96	French grey.
0	2	*Matti* band*		
3	4½	Coal	19·76	Ecru drab.
43	9½	Total		

CARBONACEOUS SHALE FLOOR.

The proximate analysis of the average sample excluding bands marked * is as follows :

	Per cent.
Moisture	1·06
Ash	18·84
Volatiles	29·68
Fixed carbon	50·42
	100·00

Calorific value of the coal	6, 424 calories or 11,354 B t.u.
Nature of the coal	Caking and swelling.
Colour of the ash	Ecru drab.

The annual output of the Sawang colliery is given below :

Year	Tons
1924	27,065
1925	59,406
1926	57,969
1927	91,628
1928	1,25,333
1929	1,20,790
1930	1,00,522
1931	72,969
1932	71,515
1933	59,246
1934	59,597
1935	52,378
1936	54,402
1937	65,517
1938	52,794
1939	49,403
1940	47,604
1941	56,406
1942 . . .	9,275

Year	Tons
1943	58,297
1944	57,739
1945	65,982
1946	63,913
1947	47,695
1948	49,983
1949	38,116
1950	35,134
1951	38,250

The approximate number of labour employed in 1946 in the Colliery was about 950.

Palihari-Gurudih Area : Pipradih Colliery

The westernmost outcrop of the Kargali seam is noted in the Palihari-Gurudih area which was first examined by the author in May, 1944 on a request from Bokaro and Ramgur Limited. As a result of the investigations the Company started developing the area : the Pipradih Colliery was started in October, 1944, when quarrying at the outcrop was commenced. This area lies immediately to the west of the Sawang Colliery property and is cut off to the west by a W.N.W.—E.S.E. fault (Dr. Fermor's 'Palm Tree Fault') which has thrown down the seam several hundreds of feet south-west of the fault. The fault, on account of the covered nature of the country, is not traceable except for a short distance in the north-western corner of the area. Development of the property accompanied by further prospecting by the Company revealed certain features which led the author to re-visit the area and examine certain parts again. This corroborated the geological mapping which had previously been hazarded on a covered and unexplored ground.

The thickness of the Kargali seam varies from about 38 ft. in the western portion to 49 ft. in the eastern end. The seam dips south-west to south-south-west at 15°. The quarry has exposed, about the middle portion of the outcrop within the property, a mica-peridotite sill towards the top of the seam. The damage caused by the intrusion apparently is not very widespread as none of the boreholes put down to meet the coal seam proved any intrusive rocks. Before 1944 the Company had put down five boreholes in the property ; the details of the rocks and coal seams met with are given in Plate X. Some minor faults have been exposed in the quarries after a little progress has been made in the work.

The Kargali seam lying immediately to the east of this area was previously worked in the two parallel quarries (since abandoned) belonging to the Sawang colliery. A fault runs between the two quarries and is traceable north-westwards in the *nala* north of the area. The outcrop of the Kargali seam in the Pipradih colliery area has been proved to be the westerly continuation of that in the southern of the

two quarries in Sawang area and it has, also, been proved that the northern outcrop continuing for a short distance in the Pipradih property has been cut off by the fault separating the two quarries.

During 1947-48 heavy machinery were at work at this outcrop for over a year removing the overburden and extracting the coal machanically.

The following are the details of the sections of the Kargali seam sampled together with the analytical results :—

Kargali seam—Pipradih Colliery, Western quarry (Quarry No. 1).

Thickness		Description	Ash content	Colour of ash
Ft.	in.	DECOMPOSED SHALE ROOF	Per cent.	
1	0	Coal	21·20	White.
0	1½	Shaly coal*		
3	0	Coal	22·08	Pink
0	11	Coal	30·08	Buff pink.
0	2	*Matti* band*		
2	4	Coal	25·86	Vinaceous.
0	3	*Matti* band*		
3	0	Shaly coal . . .	24·94	Ecru drab.
0	8	Coal	14·34	Chocolate colour.
0	1	*Matti* band*		
1	0	Coal	30·30	Vinaceous pink.
0	3	Shaly coal*		
0	7	Coal	20·84	Vinaceous.
0	3	Shale*		
0	4	Coal	21·50	Chocolate.
1	6	Coal	21·74	Vinaceous pink.
0	8	Laminated shaly coal*		
1	10	Coal	18·62	Pinkish vinaceous.
0	2	Shaly band*		
0	10	Coal	40·82	Vinaceous buff.
3	0	Coal	25·92	Light vinaceous buff.
0	1	Shaly coal*		
0	8	Coal	14·26	Light vinaceous buff.

Kargali seam—Pipradih Colliery, Western quarry (Quarry No. I)—contd.

Thickness Ft.	In.	Description	Ash content Per cent.	Colour of ash
0	1½	Shaly coal band*		
0	7	Coal, shaly . . .	24·00	Vinaceous buff.
1	2	Coal	23·02	Vinaceous.
2	0	Shale and shaly coal with mica-peridotite sill*.		
1	3	Coal, shaly . . .	23·50	Vinaceous.
0	3	*Matti* band (variable)*		
1	8	Shaly coal with streaks of vitrain.	23·96	White.
0	11	Coal	24·54	Pale violet.
0	3	Coal (coarse grained) .	27·78	Heliotrope-purple.
0	4	Coal	18·30	Buff pink
0	2	Shaly band*		
1	2	Coal	21·12	White.
0	½	*Matti* band*		
1	7	Coal	27·08	White.
0	½	*Matti* band*		
1	4	Coal	26·20	Pinkish buff.
0	1	Shaly coal band*		
1	1½	Coal	35·88	White.
0	3	Shaly coal*		
1	6	Coal	23·22	White.
38	6½	Total.		

SHALE FLOOR

The proximate analysis of the average sample excluding bands marked * is :—

	Per cent.
Moisture	1·18
Ash	25·46
Volatiles	23·92
Fixed Carbon . . .	49·44
	100·00

Calorific value of the coal	5,855 calories or 10,540 B. t. u.
Nature of the coal	Caking.
Colour of the ash	Ecru drab.

Kargali seam—Pipradih Colliery, Eastern quarry (Quarry No. 2).

Dipping S.W. to S.S.W. at 15°.

Thickness Ft.	in.	Description	Ash content Per cent.	Colour of ash
		CARBONACEOUS SHALE ROOF		
4	10	Coal including two ¼″ *matti* bands.	24·02	Cream buff.
0	3	Shaly coal band*		
2	8	Coal	24·82	Pinkish white buff.
0	2	*Matti* band* (varying from 0″ to 5″).	Prominent band.	
3	9	Coal including 1″ shaly coal and ¼″ *matti* bands.	24·94	White.
0	1	*Matti* band* (varying from 0″ to 2″).		
3	4	Coal including ½″ *matti*, 1″ shaly coal and ½″ *matti*.	25·82	Pinkish white.
0	2½	*Matti* band* . . .	Prominent band.	
2	3½	Coal including two ¼″ *Matti* bands.	19·08	Vinaceous buff.
0	2½	Shaly band* . . .		
1	3	Coal including ½″ shaly band.	32·52	Cream.
0	1½	*Matti* band* (varying from 0″ to 3″).		
1	5	Coal	17·82	Pinkish grey.
0	2	*Matti* band* (varying from 0″ to 4″).		
1	5	Coal including ¼″ *matti* band.	27·18	White.
0	2	Soft band*		
3	11	Coal	27·88	Pinkish grey.
0	2½	*Matti* band*		..

Kargali seam—Pipradih Colliery, Eastern quarry (Quarry No. 2)—contd.

Thickness Ft.	in.	Description	Ash content Per cent.	Colour of ash
0	11	Coal including ¼″ *matti* band.	27·60	Grey.
0	2	Shale* .		
1	9	Coal	22·98	Pinkish white.
0	2½	Soft and *matti* band*		
1	0	Coal	32·16	Pinkish white.
0	3	*Matti* band*		
0	7½	Shale*		
0	9	Mica-peridotite sill with *Jhama**.		
0	8	Coke	28·96	Brick-red.
0	11½	Coal including ¾″ shaly band	20·32	Pinkish vinaceous.
0	1½	*Matti* band*		
0	10½	Coal	32·04	Vinaceous pink.
0	2	Shale*		
0	10½	Coal	25·06	Pinkish vinaceous.
0	5	Coke with 1/8″ shale .	36·02	Chocolate colour.
0	10	Coal	26·70	Vinaceous pink.
0	1½	Shaly coal*		
6	7	Coal including three 1/8″ and two ½″ *Matti* bands and two 1″ shaly bands.	23·16	Ecru drab.
0	2	Shaly band*		
0	11	Coal	23·40	Ecru drab.
0	2½	*Matti* band*		
0	7½	Coal including two 1/8″ *matti* bands.	28·86	Vinaceous.
0	3	Shaly band*		
3	0	Coal	35·84	Ecru drab.
48	0	Total		

SHALE FLOOR

The proximate analysis of the average sample excluding band marked * is as follows :

	Per cent.
Moisture	0·94
Ash	25·48
Volatiles	23·72
Fixed Carbon	49·86
	100·00

Calorific value of the coal	5,945 calories or 10,700 B. t. u.
Nature of the coal	Caking.
Colour of the ash	Ecru drab.

From the analyses it would appear that the quality of the seam has deteriorated considerably within a short distance from the Sawang colliery where the ash content was found to be 18·84% whereas the Pipradih samples showed the ash percentage to be over 25. Doubts have sometimes been raised if the outcrop was not of the next lower seam, namely, the Bermo seam. From the sections sampled, and considering the nature of the roof and the floor and also following the continuity to the Kargali seam outcrop in the adjacent Sawang property, it appears pretty certain that the outcrop in question is that of the Kargali seam.

Kathhara Area

It has already been mentioned that although the Kargali seam is presumed to occur in the area enclosed between the Borea and the Kathhara faults its actual existence was not proved so far. As Bokaro and Ramgur Ltd. were anxious to develop the Bokaro coalfield, the Geological Survey of India was approached for assistance in selecting some borehole sites in the area enclosed by the two big faults, so that the company could put down boreholes for proving the Kargali seam or any other workable seam. The author was deputed by this Department to take up the job. After detailed examination of the area and after careful consideration of the available evidence he selected, at the first instance, three borehole sites, Nos. 1, 2 and 3 (marked on the 4"=1 mile map). Borehole No. 1 was recommended to be situated 1½ furlongs W. N. W. of Uchitdih (23°45½′ : 85°52½′), No. 2, two furlongs S. S. E. of Kathhara (23°46′ : 85°53¼′) and No. 3, three furlongs S. S .W. of Bandh (23°46′ : 85°52′). It was also suggested that borehole No. 1 hould be put down first and results proving encouraging, the other two oreholes should be undertaken. Accordingly, borehole No. 1 (known

as the Kathhara Borehole No. 1) was put down first. It had cut through the following seams from the top :—

Coal seam.	Depth from the surface.
15 ft. Coal Seam	62 ft.
9 ft. Seam including thick shale bands	100 ,,
4 ft. 4 in. Coal Seam	143 ,,
5 ft. Coal Seam	171 ,,
1 ft. Coal Seam	236 ,,
118 ft. Kargali Seam	340 ,,

The boring was stopped after it had passed through the Kargali seam. Borehole No. 2 was next taken up but unfortunately it did not prove any of the seams including the Kargali as met with in the borehole No. 1. However, all the seams as mentioned above were met with at corresponding depths in Borehole No. 3. Here the top 24 ft. of the Kargali seam consisted of *Jhama* and burnt coal (?) but thereafter good unburnt and unaffected coal continued down to the bottom of the seam. The Kargali seam was proved in two sections—top and bottom—the top consisting of 63 ft. of *Jhama* and coal, and the bottom of over 55 ft. coal with a parting of 5 ft. of sandstone in between. The total thickness of the seam, therefore, comes to 115 ft. 6 in. after allowing for the inclination of the bed.

Analyses of the coal obtained from cores in Borehole No. 1 are given below :

15 ft. seam occurring at 62 ft. from the surface.

Description	Thickness Ft.	in.	Ash content of coal, % *excluding bands marked* *.
SHALE ROOF			
Coal	2	0	
Shaly band*	0	3	Top 5 ft. coal—17·75.
Good coal	6	0	
Shaly band*	0	3	Middle 5 ft. coal—16·50.
Good coal	3	0	
Heavy coarse-grained dirt band* .	0	6	Bottom 5 ft. coal—19·10.
Coal	3	0	
Total .	15	0	
SHALE FLOOR			

The proximate analyses of the whole seam excluding bands marked * are given below. The total rejection for the whole seam is 1 ft., *i.e.* 6·7% of the seam.

	Per cent.
Moisture	2·84
Ash	17·74
Volatiles	28·00
Fixed Carbon	51·42
	100·00

Calorific value of the coal	6,540 calories.
Nature of the coal	Coking ; yields very good silvery hard coke.
Colour of the ash	White.

In the Company's Trench No. 3, the 15 ft. seam, named as the Kathhara seam, gave the following section :—

Description	Thickness Ft.	in.	Ash Per cent.
CARBONACEOUS SHALE ROOF			
Coal	0	10	15·90
Matti and shale*	0	1	..
Shaly coal	0	4	23·90
Weathered material with ferruginous band*	0	3	..
Bony coal	0	8	20·90
Shale band*	0	2	..
Coal with ½″ ferruginous band (excluded)	3	10	12.60
Shaly band containing ferruginous stuff*	0	4½	..
Coal including one 1½ in. and another ferruginous bands	1	0	14·30
Shale band*	0	6	..
Coal	1	0	14·50
Shale band*	0	2	..
Coal including three 1/8″ *matti* bands	2	0	10·70
Shale and *matti* band*	0	7	..
Coal	1	1	9·70
Shale band*	0	2½	..
Coal	1	5	..
Total	14	6	
CARBONACEOUS SHALE FLOOR			

Bands marked* are excluded from the samples for analysis. Total rejection is 2 ft. 4 in., *i.e.*, 16·09% of the whole section. Average ash content of the seam is 14·13%.

A sample of the 4 ft. 4 in. coal seam, which contained no pickable bands, on analysis, gave the following results :—

	Per cent.
Moisture	2·10
Ash	14·65
Volatiles	27·40
Fixed Carbon	55·85
	100·00

Calorific value of the coal	7,040 calories.
Nature of the coal	Coking ; yields compact hard coke with silvery grey lustre.
Colour of the ash	White.

A sample of the 5 ft. seam having no prominent shale bands was collected from the cores of the borehole. The results of the proximate analysis are as follows :

	Per cent.
Moisture	2·40
Ash	15·90
Volatiles	27·15
Fixed Carbon	54·55
	100·00

Calorific value of the coal	6,910 calories.
Nature of the coal	Coking ; yields very good hard coke with silvery grey lustre.
Colour of the ash	White.

The section of the Kargali seam is as follows :

Depth from surface		Thickness		Ash	Description	Remarks
Ft.	in.	Ft.	in.	Per cent.	Siliceous shale and shaly sandstone.	Roof of the seam.
340	0	0	6	. .	Grey shale.	
		2	0	20·60	Soft coal.	Section I 340′-374′ 3″. Total thickness 34′3″. Rejection of bands 2′ 3″ (shale and bony coal), *i.e.*, 6·57 per cent of the section. Average ash content of coal excluding bands is 16·92 per cent.
343	0	1	0	33·05	Bony coal.	
		2	0	19·15	Coal.	
			0	15·55	Coal.	
			0	18·40	Coal.	
		5	0	9·70	Bright coal.	
		5	0	11·20	Bright coal.	
		0	9	. .	Shaly band.	
		1	0	15·60	Coal with 3″ shale band picked off.	SELECTED section II, 343′ to 365′ 9″. Total thickness 22′ 9″. Total rejection is 1 ft., *i.e.*, 4·4 per cent. The average ash content of the section excluding bands is 14·15 per cent.
		0	3			
		0	9			
365	9	3	0	18·10	Coal.	
		3	0	23·60	Bony coal.	
		0	3	—	Shaly band.	
		1	9	24·45	Coal.	
374	3	3	6	22·50	Coal.	
		1	6	51·90	Shale coal.	Section III, 374′ 3″ to 392′ 3″. Thickness of sec. 18 ft. Rejection 2 ft. 10″ in., *i.e.*, 15·74 per cent. of the sec. The average ash content of the section is 23·37 per cent.
		0	10	46·00	Shaly coal.	
		0	4	28·20	Coal	
		0	4	38·90	Shaly coal	
		0	6	19·00	Coal	
378	0	0	6	60·25	Carbonaceous shale.	
		1	6	15·05	Coal and shaly coal.	
		0	6	34·45	Pyritic shaly coal.	
		0	10	15·25	Soft and bright coal.	

Depth from surface Ft.	in.	Thickness Ft.	in.	Ash Per cent.	Description	Remarks
		0	2		Shale band.	
385	6	4	6	22·20	Coal.	
		0	9	27·40	Coal.	
		1	6	30·45	Bony coal.	
		2	9	25·75	Shaly coal.	
		0	6		Shale band.	
392	3	1	9	25·50	Coal.	
393	6	0	9		Shale band.	
		4	0	24·80	Coal with some minor bands.	
		1	0		Shale band.	
		2	0	27·45	Shaly coal.	
		1	0	47·35	Shaly coal.	
		0	6	20·00	Bony coal.	Section IV, 393′ 6″ to 421′ 0″. Thickness 27′6″. Rejection of bands of shales and shaly coal is 8ft., *i.e.*, 29·09 per cent. of the section. The average ash content of the sec. is 20·70 per cent.
403	6	1	6	48·65	Shaly coal.	
		3	0	17·50	Coal.	
		2	0	37·00	Shaly coal.	
		1	0		Shale band.	
412	6	3	0	19·95	Coal.	
		3	0	18·70	Coal.	
		1	6	37·60	Shaly coal.	
		2	6	18·65	Coal.	
421	0	1	6	16·15	Coal.	
422	6	1	6	35·90	Bony coal.	
		2	0	21·05	Coal.	Section V, 422′ 6″ to 442′ 6″. Thickness is 20 ft. Total rejection is 6″ only, i.e., 2·5 percent. only. The average ash content of the section is 25·37 per cent.
428	6	4	0	24·10	Coal.	
		0	8	19·10	Coal.	
		2	10	25·00	Coal.	

Depth from surface		Thickness		Ash	Description	Remarks
Ft.	in.	Ft.	in.	Per cent.		
432	6	0	6	47·20	Shaly coal.	
		5	0	28·10	Slickensided coal and shaly coal.	
443	6	5	0	26·50	Shaly coal (core broken off and mostly washed off).	
443	6	1	0		Carbonaceous shale band (pyritic).	
		1	0	23·90	Coal.	
		0	2		Dirt band.	Section VI, 443′ 6″ to 456′ 2″. Thickness of section is 12′ 8″. Rejection of bands is 1′ 0″, *i.e.*, 6·57 per cent. of the section. The average ash content of the section excluding the bands is 21·85 per cent.
		2	9	19·45	Coal.	
		1	3	22·00	Coal.	
		1	8	18·10	Coal.	
		0	2		Ferruginous dirt band (pyritic).	
		0	4	20·20	Coal.	
		0	4		Dirt band (stony).	
452	6	1	4	24·80	Coal.	
		0	6	30·25		
		0	2		Dirt band (pyritic).	
456	2	3	0			
		0	6		Carbonaceous shale.	
		0	3	44·25	Shaly coal.	
		0	9		Shale.	
		0	6	44·25	Shaly band.	
		1	0		Carbonaceous shale.	
461	2	2	0		Siliceous grey shale.	

Borehole stops after another 10 feet or so in the stone.

Results of proximate analysis of Kargali seam section by section as found in Kathhara Borehole No. 1.

No. Section	Thickness of section	Rejection	Moisture	Ash	Volatiles	F. Carbon	Cal. value
	Ft. in.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cals.
I. 340'–374'3	34 3	6·57	1·95	16·92	28·17	52·96	6,760
II. 376'7"—392'3" . .	15 8	12·76	1·70	23·30	26·75	48·25	6,230
III. 393'6"—421'0"	27 6	29·09	1·60	20·60	26·10	51·70	[6,560
IV. 422'6"—442'6"	20 0	2·50	1·50	25·10	25·22	48·18	6,150
V. 443'6"—456'2"	12 8	10·52	1·45	21·85	25·00	51·70	6,520
Average for the whole seam included . .	110 1	12·80	1·70	20·81	26·57	50·92	6,460
Top selected section 343'0"—365'9" . .	22 9	4·40	1·80	14·10	29·40	54·70	7,010

NOTE.- Nature of the coal in all the sections of the seam is coking and every section yields an excellent hard and compact coke with silvery grey lustre

(*Analyst*—Late J. Gupta.)

The results of the two boreholes having proved to be encouraging Bokaro and Ramgur Ltd. carried out extensive prospecting work in the area. Relying on the data obtained from the two successful boreholes (Nos. 1 and 3) the outcrop of the topmost 15-ft. seam had been located. The Kargali Seam outcrop should have been found according to the calculations but for the intervention, nearly a furlong to the south of the Boreholes Nos. 1 and 3, of a strike fault which has thrown down the seam, thus bringing the outcrop further south of the calculated position. The dip of the seams in the borehole cores has been found to be 10°; (1 in 5 nearly). Several other boreholes have been put down in different places ; many pits and drifts have been made in the coal outcrops for proving the sections and for obtaining samples for analysis. Details of the boreholes are given in Pl. X.

Mica-peridotite intrusions in the form of dykes and sills are found in this area and have affected the Kargali seam in part. Fortunately, however, the damage caused by the intrusions does not appear to be very widespread.

The Kargali seam has been found to crop out over a distance of nearly 1¾ miles extending from Uchhitdih (23°45½′ : 85°52½′) through Bandh (23°46′ : 85°52′) to south of Jhirki (23°46′ : 85°51′). The seam occurs in the eastern portion in two sections—top and bottom—the top consisting of nearly 63 ft. of coal, the upper few feet of which have been burnt at places, and the bottom of over 55 ft. of coal, with an intervening parting of about 5 ft. of sandstone. South of Jhirki the Kargali seam has thinned down to a total thickness of 52 ft. only as proved in the Company's Borehole. The dip of the seam is in a general northerly direction, the amount of dip being 20°. The Kathhara area contains virgin coal and had not been opened uptill 1951, the year in which the survey was completed.

The proximate analysis of an average sample of the whole of the Kargali seam is as follows :

	Per cent.
Moisture	1·70
Ash	20·81
Volatiles	26·57
Fixed Carbon	50·92
	100·00

Calorific value of coal	6,460 calories.
Nature of the coal.	Caking.

Outcrops of the lower seams, namely, the Bermo and the Karo seams, have also been found in the Kathhara area ; as they are in a faulted zone they cannot be profitably quarried. Although none of the Company's boreholes has been taken down below the Kargali seam, it is presumed that in this area also the lower seams underlie the Kargali Seam.

Reserves—Kargali Seam

The reserves of the Kargali seam are as follows :

Reserves of the Kargali Seam

Name of the area	Average thickness	Average dip	Reserves in tons: 1. With overburden equal to the thickness of the seam	2. With overburden twice the thickness of the seam	3. With overburden thrice the thickness of the seam	4. Down to 1,000 ft. depth
Dhori area	..	..	..	..	..	..
Kargali area	70 ft.	6°	17,580,000	35,160,000	52,740,000	..
Bokaro area (eastern)	90 ,,	6°	9,539,000	21,260,000	38,220,000	..
Bokaro area (western)	100 ,,	10°	5,738,000	12,360,000	18,030,000	..
Gobindpur area	40 ,,	20°	945,400	1,890,800	2,836,200	23,635,000
Sawang area	40 ,,	24°	1,432,000	2,864,000	4,296,000	35,800,000
Pipradih area (eastern)	40 ,,	10°	270,100	540,200	710,300	6,752,000
Pipradih area (western)	40 ,,	15°	1,250,000	2,430,000	3,645,000	30,375,000
Kathhara area	85 ,,	20°	7,861,000	13,080,000	20,650,000	91,540,000
Total			44,615,500	89,585,000	141,127,500	

4. AMLO SEAM

Dhori-Kargali-Bokaro-Jarangdih Area

The next coal seam of some importance overlying the Kargali seam is a seam extending westwards, from the Dhori colliery through the Kargali colliery but missed in the Bokaro colliery, as far as the Pipradih colliery. It has a varying thickness, which is only 5 ft. near its outcrops in the Dhori colliery area where it is dipping west at 8°. It becomes 5 ft. 6½ in. in thickness in the underground workings there but increases to about 9 ft. at the western boundary of the colliery from where de-pillaring has fairly advanced towards the outcrop. The outcrop has been traced without any break in the Kargali area just north-west of the Manager's office at Kargali (better known as the 12 ft. seam of Kargali colliery) west of which it passes under the Gomoh-Chandrapura-Ranchi Road railway line and finally exposed on the left bank and in the bed of the Damodar river about 2 furlongs west of the pumping station of the colliery. This seam is cut off in the bed of the Damodar river by a N. N. W.—S.S.E. fault also affecting the Kargali and Bermo seams. The seam is 10 ft. 8 in. thick near the Manager's office but has thinned down considerably in the outcrop in the river near the fault mentioned above. There are several minor parallel faults which were seen to affect this seam as also the Kargali seam but in between the faults the Amlo seam is seen cropping out about 100 yds. south-east of the Bermo railway station (23°46¼′ : 85°57¾′). Beyond this series of faults the Amlo seam is found to outcrop on the left bank of the Damodar river just south-east of the Manager's Bungalow of the Bokaro colliery where it is about 4 ft. thick dipping south-west at 10°. No further outcrops of this seam are seen west of this place. But in the Jarangdih Borehole No. 4 the Amlo seam has been met with at a depth of 761 ft. from the surface and has been found to be 13 feet in thickness, which is the maximum thickness noted at any place. Dr. Fermor (1917) writes about this seam as follows :

"After comparing a careful section by Mr. Whitworth of the strata passed through in diamond-drill boring No. 1 on the Great Indian Peninsula Colliery at Kargali, I consider it probable that Mr. Ward's 12′ seam in that area is the same as my seam 15. Mr. Whitworth is working this seam (it is 10′—9″ thick in the boring) and finds the coal to be of first class quality and superior to the coal in the Kargali seam."

"The samples of seam 15 passed through in my area suggested very inferior seam, so that I made no attempt to dig it out and sample it. In view of the above, however, seam 15 should be investigated when this seam is blocked out."

The following core samples were analysed :—

No. of borehole	No. of sample	Footage	Ash
			Per cent.
II . . .	F. 72 (core) . .	19 ft.—31 ft. . .	22·70
	F. 72A (washings) .		22·42

No. of borehole	No. of sample	Footage	Ash
			Per cent.
V . . .	F. 149 (cores) . .	299 ft.—305 ft. . .	34·56
	F. 149A (washings) .		34·49
VIII . . .	F. 188 (cores) . .	741 ft. 4 in.—747 ft. . .	27·33
	F. 188A (washings) .		27·86
	F. 189 (cores) . .	747 ft.—752 ft. . .	41·88
	F. 189A (washings) .		21·02

"From the above analyses it is evident that this seam is of very variable composition, and that it would require a very liberal allowance for errors due to the samples having been obtained from bore holes before any of the above analyses could be regarded as indicating a workable seam."

The proximate analysis of the average sample excluding bands marked* is :—

	Per cent.
Moisture	1·22
Volatiles	25·83
Ash	19·38
Fixed Carbon	53·57
	100·00
Calorific value of the coal	6,460 calories or 11,628 B.t.u.
Nature of the coal	Caking.
Colour of the ash	Ecru drab.

The seam has been sampled underground in the Dhori colliery and at the quarry in the Kargali colliery. The following sections of the seam have been analysed. The results are as follows :

Amlo Seam—Dhori Colliery.

Description	Thickness	Moisture	Volatiles	F. Carbon	Ash	Calorific value		Colour of ash
	Ft. in.	Per cent.	Per cent.	Per cent.	Per cent.	Calories	B.t.u.	
CARBONACEOUS SHALE ROOF								
Coal	1 5½	1·02	25·76	46·92	26·30	5,755	10,360	Vinaecous.
Shale band*	0 7	..	..	..	..	..	..	..
Coal . . :	2 1	1·28	25·98	57·24	15·50	6,700	12,060	Smoke grey.
Shale band*	0 6	..	..	..	..	..	..	..
Coal	0 11	1·22	25·32	47·96	25·50	5,770	10,390	Ecru drab.
	6 6½							
CARBONACEOUS SHALE FLOOR								

Amlo Seam—Kargali Colliery.

Description	Thickness		Moisture	Volatiles	F. Carbon	Ash	Calorific value		Colour of ash
	Ft.	in.	Per cent.	Per cent.	Per cent.	Per cent.	Calories	B.t.u.	
CARBONACEOUS SHALE ROOF									
Coal	2	3	1·10	29·00	49·70	20·20	6,080	10,945	Pearl grey.
Shaly band	0	3½	..	..	..	..	..	..	
Coal (including ½″ shale band) . .	3	7½	1·16	30·22	52·12	16·50	6,375	11,475	,,
Matti band*	0	2	..	..	..	..	..	..	
Coal	0	10	1·08	30·44	52·84	15·64	6,445	11,600	,,
Shaly band*	0	1	..	..	..	..	..	..	
Coal	0	10½	1·12	25·88	49·80	23·20	5,990	10,780	,,
Shaly *Matti* band*	0	1	..	..	..	..	..	..	
Coal	1	8	1·38	29·70	53·32	15·60	6,525	11,745	,,
Shaly band*	0	2	..	..	..	..	..	..	
Coal	0	7½	1·16	28·78	45·60	24·46	5,755	10,175	,,
	10	8							
CARBONACEOUS SHALE FLOOR									

The proximate analysis of the average sample excluding bands marked * is given below :

	Per cent.
Moisture	1·14
Volatiles	29·36
Ash	18·12
Fixed carbon	51·38
	100·00

Calorific value of the coal	6,375 calories or 11,475 B.t.u.
Nature of the coal	Caking.
Colour of the ash	Pearly grey.

Kathhara-Sawang-Pipradih Area

No outcrop of the Amlo seam has so far been seen in the Kathhara area but the 15 ft. seam struck at a depth of 62 ft. in the Kathhara borehole No. 1 (Company's borehole B.C.F. No. 1) becomes equivalent to seam 15 of Dr. Fermor and therefore becomes the Amlo Seam in this area. The section of the seam as made out from borehole cores is as follows :

Thickness		Description	Ash content of coal excluding bands marked *	
Ft.				Per cent.
		CARBONACEOUS SHALE ROOF		
2	0	Coal		..
0	3	Shaly band*	Top 5 ft. coal	17·75
6	0	Good coal	—	..
0	3	Shaly band*	Middle 5 ft coal	16·50
3	0	Good coal	—	..
0	6	Heavy coarse grained dirt band.*	Bottom 5 ft. coal	19·10
3	0	Coal	—	..
15	0	CARBONACEOUS SHALE FLOOR		

The proximate analysis of the whole seam excluding bands marked * are given below. The total rejection for the whole seam is 1 ft., *i.e.*, 6·7% of the seam :

	Per cent.
Moisture	2·84
Volatiles	17·74
Ash	28·00
Fixed carbon	51·42
	100·00

Calorific value of the coal	6,540 calories.
Nature of the coal	Coking ; yields very good silvery hard coke.
Colour of the ash	White.

In the Gobindpur area some outcrops of coal seams overlying the Kargali seam and varying in thickness from 4 ft. to 9½ ft. have been noted in the Gantiko (Montiko) river. Although none of these seams has been sampled it appears that the 9½ ft. seam cropping out about two furlongs N. N. W. of Lahariatanr (23°47′ : 85°52′) alone or together with the 4 ft. 4 in. seam just overlying it may be equivalent to the Amlo seam. In the Sawang-Pipradih area about a furlong west of the common boundary there is an outcrop of coal which probably belongs to the Amlo seam, as judged from the stratigraphic position. Excepting this, however, there is no further outcrop of the Amlo seam, nor is the outcrop followed westwards. In the boreholes put down in Pipradih area, a 10 ft. seam occurring above the Kargali seam has been proved in borehole Nos. 1 and 4 at depths of 69 ft. and 64 ft. respectively. The core sample in the latter borehole, on analysis, shows 26·45% ash. This presumably is the Amlo seam with much deterioration in quality.

Reserves—Amlo Seam

Because of the variable nature of the Amlo seam and also due to very definite data not being available for this seam coupled with the depillared and abandoned area in the Dhori colliery, estimation of its reserves has not been attempted so far.

5. JARANGDIH SEAM

It has already been mentioned that in the Jarangdih Colliery area the Kargali seam is no longer worked. A 20 ft. seam, which the author calls the Jarangdih seam, is now being worked at Jarangdih by inclines driven in it. The seam crops out south of the Jarangdih *bazar* between the Borea fault and another fault running almost north-south and dipping north-west at 10° to 15°. The Jarangdih seam is much higher in sequence than the Kargali seam and appears to be Seam 25 in relation to the latter which is taken as Seam 13. There is, however, one discrepancy which is this—in the Jarangdih borehole No. XV (D. B. H. 3 B) (Pl. X) the Jarangdih seam is recorded to occur at a depth of 107 ft. from the surface but

actually in the colliery workings the seam is found to occur at 122 ft. at the site of Borehole No. XV. This anomaly remains so far unexplained.

The Jarangdih Seam was sampled in the underground workings and the details of the section as also the analytical results are as follows :

Jarangdih Seam—Jarangdih Colliery

Description.	Thickness Ft.	Thickness In.	Ash %	Colour of the ash
SANDSTONE ROOF.				
Shaly coal .	2	3	33·90	Grey.
Bright coal	0	7	16·70	,,
Shaly coal .	0	9	46·12	Pearl grey.
Bright coal	0	8	18·88	,,
Shaly coal .	0	6	42·16	,,
Shaly band*	0	4		
Coal	1	4	19·62	Grey.
Shale band*	0	2		
Coal (including two 1″ bands)	2	10	30·40	,,
Shale band*	0	2		
Coal, Shaly .	4	9	23·38	Pearl grey.
Shaly band*	0	6		
Coal (including 1″ *matti* band)	4	10	22·02	Grey.
	19	8		
SANDSTONE FLOOR.				

The proximate analysis of the average sample representing the seam excluding all bands marked* is given below :

	Per cent.
Moisture	1·92
Volatiles	25·80
Ash	26·12
Fixed Carbon	46·16
	100·00
Calorific value of the coal	5,725 calories or 10,306 B.t.u.
Nature of the coal	Caking
Colour of the ash	French grey

At the time of the author's visit to the colliery in February, 1945, arrangements were being made for stowing with sand to be brought from the Damodar river.

Output

A statement showing the output of Jarangdih Colliery from 1st April, 1927 to 31st March, 1951, is given below :

Year	Output in Tons
1927-28	88,396
1928-29	1,14,792
1929-30	1,16,906
1930-31	94,973
1931-32	1,11,124
1932-33	1,34,308
1933-34	1,41,386
1934-35	1,18,420
1935-36	1,03,462
1936-37	77,273
1937-38	1,04,710
1938-39	95,823
1939-40	79,053
1940-41	83,915
1941-42	77,673
1942-43	55,908
1943-44	53,695
1944-45	65,934
1945-46	58,369
1946-47	38,467
1947-48	20,575
1948-49	21,315
1949-50	30,398
1950-51	23,885

Reserves—Jarangdih Seam

The reserves of the Jarangdih Seam in the Jarangdih area will be of the order of 6½ million tons less the quantity already worked.

CHAPTER VI

DESCRIPTION OF THE COAL SEAMS IN THE BARAKAR MEASURES, WEST BOKARO

West Bokaro Colliery Area

The only available complete geological map of the area before the present re-survey was that accompanying T. W. H. Hughes' Memoir (1867), although in 1916-17 L. L. Fermor examined some of the seams near Kedla (23°48′ : 85°35½′). This area had previously been seen by R. W. Church and also by G. Lathbury who were said to have divergent views about them. Later on "about 1925 on two occasions the West Bokaro area was carefully examined by borings on behalf of the Bokaro-Ramgarh Limited Company by Dr. W. Chowdhury and later by Mr. E. H. Roberton" (Fox, 1934, p. 132). While these investigations were in progress the East Indian and Bengal Nagpur Railways had jointly taken up 7,600 bighas in this area near Kedla and although plans were completed, for some reason or other the area was not worked and later abandoned. Just before the present re-survey was taken up in 1942, the present West Bokaro Colliery area including Blocks A, B (South and North), Pundi, Basandi, Kuju-Hesagara, Dumarbera-Ara-Chainpur, and Kedla-Loiyo areas were examined in great detail accompanied by drilling, pitting, trenching, etc. by the author on the initiative of Bokaro and Ramgur Limited. The rest of the area was examined in course of the re-survey. In the following pages are given the details of the investigations :—

The geological formations met with are—

Post-Gondwana intrusive igneous rocks.

Gondwanas	Raniganj stage
	Barren Measures
	Barakar stage
	Talchir stage

Archaean rocks.

The different blocks and areas in West Bokaro are dealt with below individually :

Block B (South), B (North), A and the area to its west.

In these areas there are coal seams for which the Bokaro and Ramgur Ltd. have adopted the numbers 7, 8, 9, 10, 11, etc. beginning from the base.

It has been proved, as will be evident from the analyses given later on, that the coal belonging to the Seam No. 10 (Mandu Seam) is the best in the locality. During detailed prospecting work boreholes, drifts, trial pits, etc. were put down ; their positions are shown on the geological map.

Block B (*South*)

The coal of Seam No. 10 has usually got caking properties and is of good quality as will be seen from the following average composition :—

	Per cent.
Moisture	1·52
Ash	16·40
Volatiles	26·86
Fixed Carbon	55·22
	100·00

In the Barughutu borehole No. 1 (Pl. XI) the 10 seam is passed through at a depth of 24 ft. 3 in. from the surface and on analysis shows :

Section analysed.	Moisture.	Volatiles.	Ash.	Fixed Carbon.
	Per cent.	Per cent.	Per cent.	Per cent.
Top 5 ft. 10 in. . .	1·53	26·19	17·53	54·75
Bottom 3 ft. 10 in. . .	1·52	27·53	15·17	55·78

In the Dhardharia *nala* the 10 seam is cropping out above Drift No. 2 driven into the 9 seam, 5 ft. 10 in. thick, and is separated from the latter by a parting of 5 ft. consisting of shales and sandstones. It is dipping S. S. E. at 5° but a little down the stream the dip has changed to E. S. E., the amount of dip being nearly 6°. Just above Trial pit No. 4, a fault running in a N. N. W.—S. S. E. direction and having its downthrow on the southern side intervenes. At the acute bend in the Dhardharia *nala* the seam changes its dip to a south-westerly direction at 5°, a little further downwards to south at 12°, till in Trial shaft No. 6 in the bed of the *nala* the dip becomes 5° in an east-south-easterly direction. Here the coal is affected by surface weathering. Just at the junction of the Dhardharia *nala* with the Bokaro river a fault running in a N. N. W.—S. S. E. direction has its downthrow to its north due to which the coal seam is seen on the left bank of the river dipping S. E. to S. S. E. at 8° and is 11 ft. thick. A few feet to the south of Trench No. 1 (marked T 1) a small fault with a throw of 5 ft. 3 in. brings the 10 seam down in the left bank of the Bokaro river at the edge of the river bed. The outcrop

of the seam is seen to be burnt on the other side of the fault and could be followed to some distance down the river after which it is washed out over the low fields till it appears again on the hillside in the southeast. The fault with a throw of 5 ft. 3 in. affects here also the seam which could be traced at a higher level east of the fault. On the left bank of the Bokaro river where the 10 seam ceases to crop out, the 9 seam continues along its side and later in the bed of the river. But this is brought against an outcrop of coal, exposed on both the banks of the river, by a fault running almost in an W. N. W.—E. S. E. direction. The downthrow is on the southern side. South of this fault the outcrop has a thickness of 10 ft. 9 in. on the right bank of the river, where the coal taken from a second trench, Trench No. 2 (marked T 2) is found to contain 17·04 per cent. ash.

Block B (North)

This block lies to the contiguous north of Block B (South). The boundary between the two is practically the Chutua *nadi* which coincides more or less with the direction of a major fault. The eastern and western boundaries have been so chosen that they are either close to and in certain places coincident with some faults. The area of this block is 2,000 bighas approximately.

"Burnt outcrops" as well as baked and fused strata are noted at several places more particularly at the south-western corner and west of the top portion of the western boundary of the block. No dykes have been met with on the surface but from the existence of the burnt outcrops, and baked and fused strata, it is not unlikely that some dykes may be encountered at depth. A dolerite dyke, however, has been noted across the Chutua *nadi* further west of this area.

Previous to the present survey four boreholes, namely, Banji borehole Nos. 1 and 2 and Duru borehole Nos. 1 and 2 were put down in this block. The position of the boreholes are marked on the map. The details of coal seams met with in these borings are shown in section in Pl. XI. Mr. J. P. Evans in one of his letters said—"There are also three boreholes further northwest—Duru Nos. 3, 4 and 5 but I have no sections of these holes. The only record I have is a Note on Duru borehole No. 5, which states that a 10 ft. seam was proved at a depth of 171 ft. and that No. 7 seam (?) lower was unburnt".* There are three drifts numbered 1, 2 and 3, in the neighbourhood of the Chutua *nadi* north of the cart road from Banji to Ichakdih (23°48′ : 85°36½′) and three others, namely, 5, 6 and 7, south of this road. Additional information available is from borehole records of Barughutu boreholes Nos. 1 and 5 (Pl. XI), south and south-west of this block. To collect the data during the present survey the existing drifts have bren re-opened and new drifts Nos. 4, 10 and 11 and Trial pits Nos. 8, 9, A and B (position shown on the map) have been made. Over and above these a few other minor pits have been made to prove the continuity of coal seams but they are too insignificant to be shown on the map.

* Extract from Mr. J. P. Evans' letter, dated the 21st April, 1942.

The following are the details of sections of coal from different drifts and pits with the analytical results[1] :—

DRIFT NO. 1

Section.

Ft.	In.	
		SHALE ROOF
0	6	Coal
0	2	Shale
0	2	Coal
0	8	Shale
0	8	Coal
0	6	Shale
0	2	Coal
0	2	Shale
0	6	Coal
0	6	Shale
0	10	Coal
0	2	Shale
0	2	Coal
0	3	Shale
0	3	Coal
0	8	Shale
0	4	Coal
0	3½	Shale
0	3½	Coal
1	0	Shale with bony coal
1	8	Coal
0	7	Shaly coal
Total 10	6	

Proximate analysis :—

	Per cent.
Moisture . .	1·90
Volatiles . .	28·05
Ash . . .	20·00
Fixed Carbon .	50·05
	100·00

Nature of the coal . Coking

Colour of the ash . Biscuit brown.

DRIFT NO.

Section.

Ft.	In.	
		SHALE AND INFERIOR COAL IN THE ROOF
5	0	Coal
0	2½	Shale
0	10	Coal
0	1½	Shale
2	11	Coal
0	3	Ferruginous band
1	5	Coal
0	4	Earthy band
2	0	Coal
0	5	Earthy band
2	5	Coal
Total 15	11*	

* Includes 10 seam and part of 9th seam.

Proximate analysis :—

	Per cent.
Moisture . .	1·20
Volatiles . .	31·02
Ash . . .	14·72
Fixed Carbon .	53·06
	100·00

Nature of the coal Coking .

[1] Analyses by late J. C. Gupta, late Chemist, Dhori Colliery, done at the Dhori Colliery Laboratory. All bands other than that of coal are excludedin sample for analysis.

DRIFT NO. 3

Section

Ft.	In.	SHALE ROOF
0	7	Coal
0	2	Laminated shale
0	4	Coal
0	1	Bony band
	3	Coal
0	2	Laminated shale
1	1	Coal
0	1	Ironstone band
0	4	Coal
0	3	Bony band
1	0	Coal
0	1	Shale
0	3	Coal
0	3	Ironstone band
0	7	Coal
0	11	Shale and bony band
2	0	Hard coal
0	7	Shaly coal
Total 9	0	

Proximate analysis :—

	Per cent.
Moisture . .	4·20
Volatiles . .	29·00
Ash . .	22·90
Fixed Carbon .	43·90
	100·00

Nature of the coal . No-coking.

Colour of the ash . light Liscuit.

DRIFT NC. 4

Section

Ft.	In.	SHALE ROOF
0	8	Coal
0	2	Bony band
0	8	Coal
0	3	Bony band
1	3	Coal
0	2	Bony band
0	10	Coal
0	4	Bony band
0	6	Coal
0	2	Bony band
0	4	Coal
0	2	Laminated shale
0	5	Coal
0	4	Bony band
0	4	Coal
0	4	Shale
0	4	Coal
0	10	Bony band
0	7	Coal
0	2½	Shale
0	11½	Coal
0	3	Laminated shale
Total 10	1	

Proximate analysis :—

	Per cent
Moisture . .	2·50
Volatiles . .	27·10
Ash . .	20·75
Fixed Carbon .	49·65
	100·00

Nature of the coal . Coking.

Colour of the ash . Light biscuit.

DRIFT No. 5

Section.

	Ft.	In.		
Forming Roof	1	6	Shaly coal	Top Section
Forming Roof	1	0	Shale	Top Section
Forming Roof	0	6	Coal	Top Section
	0	4	Bony band	Top Section
	0	8	Coal	Top Section
	0	1	Shale	Top Section
	2	9	Coal	Top Section
	1	0	Shale	
	1	0	Coal	
	0	4	Shale	
	0	4	Coal	
	0	3	Laminated shale	
	0	5	Coal	
	0	3	Shale	
	0	5	Coal	
	0	3	Ironstone band	
	1	0	Coal	
	1	0	White sandstone	
	2	2	Carbonaceous shale	
	1	0	Coal (hard)	
	0	2	Shale	
	0	3	Coal	
	0	2	Shale	
	0	1	Coal	
	0	3	Shale	
	0	3	al	
	0	3	Shale	
	0	11	Coal	
	0	2	Bony band	
	1	2	Hard coal	
	1	0	Shaly coal	
	1	0	Coal	
Total	21	11		

SHALE FLOOR

Proximate analysis :—

Top Section.

	Per cent.
Moisture . .	7·10
Volatiles . .	29·25
Ash . .	20·00
Fixed Carbon .	43·65
	100·00

Nature of the coal . Non-coking.
Colour of the Ash . Light coffee brown.

Whole Section.

	Per cent.
Moisture . .	4·50
Volatiles . .	28·50
Ash . .	22·30
Fixed Carbon .	44·70
	100·00

Nature of the coal . Non-coking.
Colour of the ash . Light brown to biscuit colour.

DRIFT No. 6

Section

SHALE ROOF

Ft.	In.		
	4	Coal	Top Section
0	7	Bony band	Top Section
0	4	Bright coal	Top Section
0	8	Shale	Top Section
1	3	Coal	Top Section
0	3	Shale	Top Section
1	8	Coal	Top Section
1	0	Shale	Top Section
Total 6	1		

Proximate analysis :—

	Per cent.
Moisture . .	1·40
Volatiles . .	27·70
Ash . .	23·20
Fixed Carbon .	47·70
	100·00

Nature of the coal .. Coking.

Colour of the ash . Grey.

DRIFT NO. 7

Section.

Ft.	In.		
1	6	Bad coal (not included in sample)	Top Section
6	0	Bright Coal	

SHALE ROOF

Ft.	In.		
0	4	Coal	Not in sample
0	2	Shale	
0	6	Coal	
0	6	Bony coal	
	0	Bright coal	
0	3	Bony band	
1	4	Coal	
0	2	Ironstone band	
	9	Coal	
0	6	Shale	
1	6	Coal	
1	2	Shale	
0	8	Coal	
0	4	Shale	
0	8	Coal	
1	2	Shale	
0	6	Coal	
0	6	Shale	
1	0	Coal	
25	6		

Proximate analysis :—

Top Section.

	Per cent.
Moisture . .	1·30
Volatiles . .	27·00
Ash . .	18·65
Fixed Carbon .	53·05
	100·00

Nature of the coal . Coking.

Colour of the ash . Grey.

Whole Section.

	Per cent.
Moisture . .	1·25
Volatiles . .	26·70
Ash . .	23·80
Fixed Carbon .	48·25
	100·00

Nature of the coal . Non-coking.

Colour of the ash Coffee Browa.

TRIAL PIT No. 8

Section.

Ft.	In.		
		SHALE ROOF	
0	4	Coal	Top Section
0	2	Shale	
0	2	Coal	
0	2	Shale	
1	6	Coal	
0	3	Shale	
1	0	Coal	
0	2	Shale	
1	8	Coal	
Total 5	5		

Proximate analysis :—

	Per cent.
Moisture . .	3·00
Volatiles . .	26·60
Ash .	21·10
Fixed Carbon	49·30
	100·00

Nature of the coal . Coking.

Colour of the ash . Light biscuit.

TRIAL PIT A

Section.

Ft.	In.		
1	6	Coal (not included in sample)	Top Section
3	6	Bright Coal	
Total 5	0		

Proximate analysis :—

	Per cent.
Moisture . .	4·50
Volatiles . .	29·10
Ash . .	20·65
Fixed Carbon .	45·75
	100·00

Nature of the coal . Non-coking.

Colour of the ash . Light brown to biscuit colour.

Note.—In Drift 6 and Trial pits 8 and A the full seam could not be exposed for want of time; the analyses, therefore, are of the top section only.

From the above sections and analyses it would appear that the coal in Drifts 1, 3, 4, 5, 6, 7 and 11 and in Trial Pits 8 and A all belong to one seam and that to the 11 seam while that met with in Drift No. 2 is of the 10 seam. In Drift No. 2 the 10 seam is found closely followed by the 9 seam ; similar is the condition in Banji borehole No. 1 and in Barughutu Drift No. 1. From the records of the four boreholes in this block it is to be seen that seams lower than 11, *i.e.* 10, 9, 8, and 7, all occur at different depths and it could safely be assumed that throughout this block the lower seams are present.

The strike of the rocks in this block has been found to be in a general W.N.W.—E.S.E. direction which agrees with the observation in Barughutu Drift No. 1. The direction of the dips, however, varies from S.S.E. to S.S.W. and the amount from 5° to 20°, the dips attaining a maximum amount in the northernmost part close to the Chutua *nadi*, gradually diminishing to 5° near the southern boundary and ultimately becoming 4° in Barughutu Drift No. 1. On the northern side of the Chutua *nadi* outside this block the dips are roughly in a northwesterly direction, the amounts varying from 20° to 30°. The structure, therefore, is a simple anticlinal fold with its axis coinciding roughly with the Chutua *nadi*.

Now, if the positon with regard to the dips is such as that noted above, the question arises—how can the outcrop of the 10 seam, as met with in Barughutu Drift No. 1, come to the position as seen in Banji Drift No. 2. Also, a continuous outcrop of 11 seam could be traced through Drift Nos. 1 and 4 and another parallel outcrop of the same seam at a higher level through Drift No. 3. Outcrops of 11 seam are marked in the Kedla *nala* west of Drift No. 5 and in the *nala* meeting it above Drift No. 6 and also noted in Drift Nos. 7, 10 and 11. This is due to the Block being affected by a series of step faults more or less parallel to the direction of the strike and having their downthrow towards the north. In drawing a section in a N.N.E.—S.S.W. direction six faults and another on the Chutua *nadi* may be sufficient for explaining the general structure of the area, but it is believed that the number of faults near Banji may be actually more than what have been shown. This part of the country shows signs of much faulting and it has not been possible to determine accurately the actual number of faults on account of the soil cap. The total downthrow of the 10 seam, as seen from the outcrops in the Barughutu Drift No. 1 and Banji Drift No. 2, due to the of the of step faults, calculated from the section, is about 440 ft. One series major faults, the Chutua fault, is passing through the spring continuing along Chutua *nadi* north of Drift No. 2 and then between Duru borehole No. 1 and Drift No. 4 and later meeting again into the Chutua *nadi* near its bend north-east of Duru borehole No. 2.

As regards other faults in this block, both cross and oblique, one major fault is running almost parallel to the western boundary starting from the Chutua *nadi*, passing through east and west of Kasmar and Banji respectively and continuing south-westwards a few yards east of Barughutu borehole No. 5. There is another fault which originates from the fault north of Drift No. 3 and continues from west of Banji borehole No. 2 between this and Drift No. 6, running almost parallel to the Kedla *nala*. This could be traced South-south-east of Chowdhury's borehole No. 6 outside this block. The downthrow side is towards

the No. 2 Banji borehole. Other minor faults are in the *nala* west of Duru borehole No. 2 with the downthrow towards this borehole.

As has already been mentioned, the coals of different seams from 11 seam down to the 7 underlie throughout this area excepting, of course, in some places where the uppermost 11 seam has been denuded away. This is corroborated from the records of the four boreholes.

The percentage of ash for the different seams is as follows :

Seam 11—Ash percentage varies from 21·1 to 25·72

,, 10— ,, ,, ,, ,, 11·5 to 16·51
,, 9— ,, ,, ,, ,, 18·66 to 26·7
,, 8— ,, ,, ,, ,, 24·76 to 27·2
,, 7—Ash percentage is 23·4

It would appear from the above that some of the coals are of good quality and that the one belonging to the 10 seam is undoubtedly the best. Dr. Fox (1934, p. 132) has made the following general remarks about the coals of this area :—" The quality of the seam is such that, in nearly all cases, it is expected that hand-picking will be necessary to get a satisfactory grade of coal." These remarks apply equally to the coals of this block as well. But naturally hand-picking would be a laborious and necessarily, a costly process. It is, therefore, necessary to wash these coals with the object of bringing down the ash percentage.

Out of the whole block the area unaffected by any fault or by faults of minor consequence, is more than half the total area and comes to 1,200 bighas. The estimated reserves of coal in this area would be roughly 36 million tons taking a total thickness of 60 ft. for all the workable seams from 10 down to 7 seam.

Block A

In the southern portion of Block A coal seams are cropping out in the Jharna *nala* and the country to its west outside the block in the Karma *nala*, south of the hot spring site (23°47′ : 85°34′). In this block Bokaro and Ramgur Ltd. have driven several drifts, namely, Drift Nos. A, B^2, B^3, C, D, E, F, G and 7 into the coal, the position of the drifts being shown on the map. The samples of coal collected from these places have the following analyses* :—

Drift No.	Thickness of section. Ft.	In.	Moisture Per cent.	Volatiles Per cent.	Ash Per cent.	Fixed Carbon Per cent.	Remarks
A .	11	6	5·25	27·60	22·02	50·37	Non-coking.
B^2 .	10	9	2·08	27·74	21·40	50·86	
B^3 .	10	8	1·15	28·02	21·25	50·73	
C .	10	1	4·75	28·46	22·12	49·42	Non-coking.
D .	10	11	1·88	28·34	20·40	51·26	Caking.
E .	10	7	1·84	27·52	21·06	51·42	,,
F .	10	4	1·27	27·48	22·74	49·78	,,
G .	10	5	1·24	27·32	22·84	49·84	
7 . .	10	3	1·56	25·32	23·74	50·94	Caking.

* All the analyses are on a moisture-free basis ; analytical reports kindly placed the author's disposal by Messrs. Anderson, Wright & Co.

From the analyses it would appear that the coal belongs to one seam and this is the 11 seam.

In the Parsabera area three boreholes, Nos. 1, 2 and 3, have been put down ; the details of the coal seams met with in each hole are shown in section in Pl. XI. From the above it will be seen that the 10th seam is met with in each hole at the following depths from the surface :—

Borehole No. 1	91 ft.
,, No. 2	132 ft.
,, No. 3	171 ft.

The 11 seam has been washed away at the sites of the above boreholes and the condition is the same in Barughutu boreholes Nos. 1, 4, 5, 6, 7 and 8. Structurally the area is folded into anticline and syncline, the arch of the anticline containing the 11 seam having been denuded away in the area lying between Drifts B^2 and B^3. The maximum dip of the limbs of the folds does not exceed 10°. The outcrop is affected by several faults chief amongst which are the two running approximately in E.N.E.—W.S.W. and W.N.W.—E.S.E. directions. These two faults as also a third minor one appear to meet just W.S.W. of the Hot Spring. There are two other faults which appear to meet north-west of Drift A.

The E.N.E.—W.S.W. fault passing just south of the Hot Spring eastwards swings a little to the north and could be located between Chowdhury's borehole Nos. 11 and 6. It appears that the throw due to this fault is greater near the Hot Spring than to the north of Chowdhury's borehole No. 11. If a section is drawn along Barughutu borehole Nos. 1, 4, 5, 6, 7 and 8, it will be seen that a fault with its approximate position near the Hot Spring will be responsible for a downthrow of 64 ft. The author is of the opinion that this throw of 64 ft. is due not to one fault alone but to the combination of at least three faults.

Pundi-Basaudi Area

The above four areas, located west, south and southwest of Block B (South), contain six blocks which are as follows :

(1) Pundi area coinciding with the Pundi Block,

(2) Basaudi area coinciding with the Basaudi Block,

(3) Kuju-Hosagara area cotaining Kuju, Hosagara and Murpa blocks, and

(4) Dumarbera-Ara-Chainpur area containing Dumarbera-Ara block.

The coal-bearing rocks in each of the above blocks belong to the Barakar series, a general description of which is not repeated here again. Other rocks, wherever found, have been fully described.

Pundi Block (Block K of Bokaro and Ramgur Ltd.)

The Pundi block lies to the contiguous west and south-west of Block B (South) and is bounded on the north by the Banji fault which swings round to form its western boundary also, on the south by the Duni fault while on the east it extends as far as Block B (South). The total area is 5,000 bighas approximately.

The area is occupied by the rocks of the Barakar stage. " Burnt outcrops " together with baked and fused strata are found at several places of which special mention may be made of the country around Bhutahitoli (23°47½′ : 85°32′) and to its east and south-east on the right bank of the Bokaro river and also continuing north-east towards Sunughututoli (23°48′ : 85°32′). Similar " burnt outcrops " are also seen on the top of the hill south of the junction of the Baglatoa *nala* and the Bokaro river.

Excepting the two major faults, Banji and Duni faults, there are two other fairly big faults, one running almost in an east-west direction through the junction of the Dibdoha *nala* with the Bokaro river and the other branching off from the Banji fault and proceeding southwards through Bhutahitoli. In addition, there are a few minor faults with small throws. The area is unaffected by the intrusive igneous rocks.

The only previous information about this block is available from Roberton's report wherein it is stated that a coal seam, about 10 ft. thick, with an alternating series of coal and shale is outcropping along the northern boundary and that " the best section, sampled in No. 13 (Barughutu) trial shaft was clean coal, 7½ ft. in thickness, and gave an ash percentage of 24½". Since then no further work had been done in this area before the present survey.

As this block is situated next to Block B (South) it can reasonably be expected that the seams occurring in the latter, at least the majority of them, should also underlie this area. A survey of the block disclosed several outcrops of coal, some of which are of fairly thick seams running to 25—30 ft. To prove the coal seams two boreholes, namely, the Barughutu borehole No. 9 and the Pundi borehole No. 1, were put down as shown on the map. Several drifts and trial pits had been made in the outcrops of coal for obtaining samples for analyses. The details of the sections analysed, together with the corresponding results, are given below :

Barughutu Drift No. 7 *11a seam.*

Section.	Thickness. Ft.	In.	Analysis.	Per cent.
SHALE ROOF				
Coal . . .	0	4	Moisture . .	2·10
Shale . .	0	1	Ash . .	16·70
Coal . . .	0	11		
Shale . .	0	2	All bands other than those of coal excluded in sample for analysis.	
Coal . . .	0	7		
Shale . .	0	1		
Coal . .	1	8		
Shale . .	0	2		
Coal . . .	0	2		
	4	2		

Barughutu Drift No. 8 — *10 and 9 seams.*

	Section.	Thickness. Ft.	In.
	SHALE ROOF		
I	Coal	1	1
	Shale	0	5
	Coal	1	6
	Dull Coal	0	7
	Coal	1	8
	Shale	1	6
	Coal	3	3
	Ferruginous band	0	4
II	Coal	0	4
	Shale	0	2
	Coal	0	9
	Dull Coal	0	2
	Coal	0	9
	Shale	0	1
	Coal	0	3
	Shale	0	9
	Coal	0	9
	Bony coal	0	4
III	Coal	2	4
	Shale	0	1
	Coal	2	2

Analysis.

(Sample obtained by mixing those of the four sections.)

	Per cent.
Moisture	1·30
Volatiles	26·10
Ash	21·34
F. Carbon	51·26
	100·00

Calorific value of the coal—6,500 calories.

Nature of the coal Coking.

Colour of the ash Ligh brown.

The average rejection for the whole section will be 25·07 per cent. All bands other than those of coal excluded in sample for analysis.

Barughutu Drift No. 8—contd. *10 and 9 seams.*

Section.

		Thickness. Ft. In.
IV	Shale . . .	0 6
	Coal . . .	1 0
	Shale . . .	0 7
	Coal . . .	0 3
	Shale . . .	0 2
	Coal . . .	0 4
	Laminated shale .	0 7
	Coal . . .	1 2
	Ferruginous band .	0 3
	Coal . . .	0 7
	Shale . . .	0 1
	Coal . . .	0 9
	Shale . . .	0 1
	Coal . . .	1 1
	Shale . . .	0 2
	Coal . . .	0 8
	Shale . . .	0 1
	Coal . . .	1 0
		27 7

The average rejection for the whole section will be 25·07 per cent. All bands other than those of coal excluded in sample for analysis.

Barughutu Drift No. 9 *8 seam.*

Coal . . .	3 7
Shale . . .	0 3
Coal . . .	0 4
Shaly coal . .	1 1
Coal . . .	5 9
Shale . . .	4 8
Coal . . .	1 5
	17 1

Analysis.

	Per cent.
Moisture .	1·70
Ash . .	24·50

Barughutu Drift No. 10. *10 and 9 seams.*

Section.

SHALE ROOF	Thickness Ft.	In.
Coal . . .	1	9
Shale . . .	0	2
Coal . . .	1	6
Shaly coal . .	0	3
Shale . . .	1	1
Coal . . .	3	2
Matti (Ferruginous band).	0	3
Coal . . .	0	8
Laminated shale .	0	5
Shale . . .	0	3
Coal . . .	0	3
Shale . . .	0	4
Coal . . .	0	2
Bony coal . .	1	2
Coal . . .	0	2
Shaly coal . .	1	6
Coal . . .	1	4
Laminated shale .	0	10
Bony shale . .	0	2
Coal . . .	0	9
Shale . . .	0	3
Coal . . .	0	7
Shale . . .	0	6
Coal . . .	1	2
Shale . . .	0	3
Coal . . .	3	0
Shale . . .	0	2
Coal . . .	0	11
Shale . . .	0	1
Coal . . .	1	0
	24	1

Proximate analysis. :—

	Per cent.
Moistur .	2·80
Volatiles .	22·50
Ash . .	20·70
F. Carbon .	54·00
	100·00

Calorific value of the coal—6,580 calories.

Nature of the coal—Coking.

Colour of the Ash—Grey with light pinkish tint.

All bands other than those of the coal excluded in sample for analysis.

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Pundi Drift No. 1 *11 seam.*

Section.

SANDSTONE ROOF	Thickness. Ft.	In.
Decomposed stuff .	3	0
Coal . . .	1	2
Bony coal . .	0	6
Coal . . .	1	7
Ferruginous band .	0	4
Coal . . .	0	8
Shale . . .	0	4
Shaly coal .	0	5
Shale . . .	0	11
Shaly coal . .	0	6
Coal . . .	1	3
Pyrite . . .	0	2
Coal . . .	0	6
Shale . . .	0	6
Shaly coal . .	0	4
Coal . . .	0	4
Shaly coal . .	0	10
Shale . . .	1	0
Coal . . .	0	10
Shale . . .	0	2
Coal . . .	0	9
Shale . . .	0	5
Coal . . .	0	6
Shale . . .	0	7
Coal . . .	1	0
Shale . . .	4	2
Bony coal . .	0	6
Coal . . .	2	0
Bony coal . .	0	4

Proximate analysis :—

	Per cent.
Moisture .	5·40
Volatiles .	23·65
Ash . .	22·60
F. Carbon .	48·35
	100·00

Calorific value of the coal—6,130 calories.

Nature of the coal—Coking.

Colour of the ash—Light brown or of biscuit shade.

All bands other than those of coal excluded in sample for analysis.

Pundi Drift No. 1—contd. *11 seam.*

Section.

Thickness	Ft.	In.
SANDSTONE ROOF		
Coal . . .	0	7
Bony coal . .	0	2
Coal . . .	0	4
Bony coal . .	0	2
Coal . . .	0	6
Shaly coal . .	1	0
	28	4

Pundi Drift No. 2 *11 seam.*

Section.

Thickness		Ft.	In.
SHALY SANDSTONE ROOF			
Decomposed stuff	These are not included in the sample.	5	0
Shale . .		0	6
Coal . .		0	6
Shale . . .		1	0
Coal . . .		0	4
Ferruginous band .		0	4
Coal . . .		0	4
Ferruginous band .		0	2
Coal . . .		0	8
Ferruginous band .		0	4
Coal . . .		0	2

Proximate analysis :—

	Per cent.
Moisture .	2·50
Volatiles .	26·70
Ash . .	20·80
F. Carbon .	50·00
	100·00

Calorific value of the coal 6,420 calories.

Nature of the coal Coking.

Colour of the ash—Grey.

Pundi Drift No. 2—contd. *11 seam.*

Section. SHALY SANDSTONE ROOF.	Thickness Ft.	In.	
Shale . . .	2	0	All bands other than those of coal excluded in sample for analysis.
Coal . . .	0	2	
Bony band . .	0	4	
Shaly coal . .	1	5	
Shale . . .	0	2	
Coal . . .	1	0	
Bony band . .	0	1	14′ 2″ Rejection of bands of this section is 8′ 11″. The percentage of the rejection is 62·4.
Coal . . .	0	2	
Bony band . .	0	3	
Coal . . .	0	7	
Shaly coal . .	0	10	
Coal . . .	0	6	
Shale . . .	0	1	
Coal . . .	0	4	
Shale . . .	3	2	
Bony band . .	1	0	
Shale . . .	0	1	
Bony band . .	1	0	
Coal . . .	0	6	
Bony ba. . .	0	6	
Coal . .	0	8	
Bony band . .	1	0	
Shaly coal . .	0	5	
Coal . . .	0	10	
Shaly coal . .	0	6	
Coal . . .	0	8	
	27	7	

Barughutu Trial Pits

Triat Pit No. V. *11a seam.*

Section.

Shale Roof.	Thickness. Ft.	In.	Analysis.	Per cent.
Coal . . .	0	9		
Shale . . .	0	1	Moisture .	3·20
Coal . . .	0	5	Ash . .	15·9
Shale . . .	1	0		
Coal . . .	0	2		
Shale . . .	0	8		
Bony coal . .	0	4		
Coal . . .	0	6		
Shale . . .	0	1		
Coal . . .	2	6		
	6	6		

Trial Pit A. *8 seam.*

Section. Shale Roof.	Thickness. Ft.	In.	Analysis.	Per cent.
Coal . . .	1	6	Moisture .	2·50
Shale . . .	1	5	Ash . .	25·60
Coal . . .	3	10		
Shale . . .	0	2		
Coal . . .	4	3		
Coal (hard) . .	4	5		
	15	7		

Trial Pit B

Bottom of Pit A — *Middle of 8 seam*

Section.

	Thickness.	
SHALE ROOF.	Ft. In.	
Shaly coal . .	0 4	
Shale . . .	2 5	
Coal . . .	1 1	
Shaly coal . .	0 6	
Coal . . .	1 10	
	6 2	

Analysis.	Per cent.
Ash	15·90

All bands other than those of coal excluded in sample for analysis.

Trial Pit C — *11a seam.*

	Thickness. Ft. In.
Coal . . .	3 10

Analysis.	Per cent.
Moisture .	1·80
Ash . .	31·50

Trial Pit D — *11 seam.*

Section.

	Thickness.
SHALE ROOF	Ft. In
Coal . . .	0 2
Shale . . .	0 8
Coal . . .	3 10
Pyrite . . .	0 6
Coal . . .	0 7
Shale . . .	0 9
Coal . . .	4 0
	10 6

Analysis.	Per cent.
Ash . .	16·6

Trial Trench No. 2 Pundi. *11 seam.*

Section.

SHALE ROOF.	Thickness. Ft.	In.		Analysis. Per cent.
Coal, decomposed stuff . .	0	3	4 ft.-1 in. Not included in sample.	Ash. (8·0)
Ferruginous band, decomposed stuff.	0	2		
Coal, decomposed stuff .	0	4		
Shale ,, ,, .	0	6		
Coal ,, ,, .	0	4		
Shale ,, ,, .	0	1		
Coal ,, , .	0	3		
Shale ,, ,, .	1	0		
Coal ,, ,, .	0	9		
Shale ,, ,, .	0	2		
Coal ,, ,, .	0	1		
Ferruginous band . . .	0	2	5 ft.-1 in. All bands other than those of coal excluded in sample for analysis.	
Coal	0	2		
Ferruginous band . . .	0	6		
Coal	1	3		
Shale	0	3		
Coal	1	1		
Shale	0	2		
Coal	0	5		
Shale	0	1		
Coal	1	2		

The drifts and trial pits have been made in the different seams as follows :

Pundi drift Nos. 1 & 2, Trial trench No. 2 Pundi and Trial pit D—in the topmost seam.

Barughutu drift No. 7, Trial pit Nos. 7 & C—in the next lower seam,

Barughutu drift Nos. 8 & 10—in the next lower seam,

Barughutu drift No. 9, Trial pits A & B—in the next lower seam.

In the Barughutu borehole No. 9, which went down to a depth of 275 ft. 11 in., the following coal seams have been met with :—

Ft.	In.			
10	3	Seam at 21 ft. 1 in.		
3	9	,, at 37 ft. 1 in.	Ash . .	16·7 per cent
30	1	,, at 152 ft. 7 in.		
13	3	,, at 238 ft. 4 in.		

In the Pundi borehole No. 1 (total depth 254 ft. 11 in.) the coal seams met with are given below :

Ft.	In.			
30	8	Seam at 13 ft. 2 in. (includes a 5 ft. 1 in. band of bright coal containing 17·1 per cent. ash).		
32	4	,, at 81 ft. 4 in.		Analysis.
10	6	,, at 185 ft. 3 in.	Ash .	29·00 per cent.
14	0	,, at 226 ft. 6 in.	Ash .	28·85 ,,

The topmost seam in No. 9 borehole together with the 3 ft. 9 in. seam appears to be the same as the 30 ft. 8 in. seam with 5 ft. 1 in. section of good coal in Pundi borehole No. 1 with the difference only in thickness which is practically double in the latter case. This seam, so far as the stratigraphic position is concerned, is the 11 seam, as also corroborated from the ash content. This variation in thickness in the 11 seam is by no means unusual. Underlying the 11 seam in the Barughutu borehole No. 9 is the 30 ft. 1 in. seam which is much thicker than the 10 seam as is usually found in Block B (South) and there is a corresponding seam, 32 ft. 4 in. thick, as met with in the Pundi borehole. The 13 ft. 3 in. seam in the No. 9 borehole has also a corresponding seam, 10 ft. 6 in. thick, in the Pundi borehole. The question naturally arises—where is then the 10 seam and what is actually this 30 ft. 1 in. seam in No. 9 borehole. In Barughutu Drift No. 8 this latter seam has been sampled and the analyses in four sections are as follows :

	Thickness.	Moisture.	Volatiles.	Ash.	Fixed Carbon.
	Ft. In.	Per cent.	Per cent.	Per cent.	Per cent.
Section I . .	9 0	1·60	26.20	21·30	50·90
Section II . .	4 0	1·20	24·80	24·50	49·50
Section III . .	4 7	0·80	27·20	20·60	51·40
Section . .	8 10	1·20	26·00	20·35	52·45

All the above samples proved to be of caking quality.

From the above analyses none of the sections, however, could strictly be made to correspond to the 10 seam, as, although this coal produces good hard coke, the ash content is higher. But from field evidence this seam appears to occupy the position of the 10 seam.

A mixed sample from No. 10 Barughutu drift gives an ash percentage of 20·70 which, however, is not bad judging from the fact that the coal was slickensided and much fractured, in the cracks of which the percolating waters from the top might have left some earthly matter. Here, the presence of the 10 seam could be imagined without much difficulty. Thus it will be seen that the thick coal seam, second in position from the top in the two boreholes and exposed in drift Nos. 8 and 10, contains the 10 seam and appears to be a combination of this seam with the underlying 9 seam. Such examples of joining of seams are not rare in this field ; another instance of this is to be seen in Banji drift No. 2 wherein the 10 seam is joined by the 9 seam. The next lower seam as met with in drift No. 9 and Trial pits A and B appears to be the 8 seam. The lowest seam in the Pundi borehole is considered to be the 7 seam, having taken into account its thickness also. Leaving aside now the correlation of the seams what stands out prominently in this block is the occurrence of a more or less 30-ft. coal seam underlain by some other seams.

The strike of the rocks is in a general N.E.—S.W. direction. The dips usually vary in direction from E.S.E. to S.S.E. and in amounts from 4° to 8°, although locally in the Bokaro river south of Sunughututoli the dip is N.N.E. at 15°. Such unusual variation is due to faults.

The geological structure is simple—the block is traversed by a series of step faults roughly parallel to the direction of the strike. The downthrow due to the Banji fault, west of Pundi Drift No. 1, is less than 20 ft. although increasing at Pundi (23°46½′ : 85°31½′).

From the borehole records it will be seen that the 30-ft. seam under the 11 seam is underlying the major northern half of the block excepting the small area E.S.E. of Bhutahitoli where probably the coal has been burnt. This seam can reasonably be expected to extend also to the remaining portion of the block as far as the Duni fault, a fact which was intended to be proved by putting down a borehole about ¾mile S.S.E. of Pundi borehole No. 1. The boring was actually started but due to several difficulties having come up it was ultimately abandoned. This coal seam contains shale and bony coal bands which would necessarily require hand-picking to bring it to the standard of a satisfactory grade. The coal, after having been separated from the shale and bony coal bands, yields a very good hard coke but has a slighlty higher percentage of ash. Washability tests have since been carried out yielding satisfactory results. The reserves calculated for an average of 19 ft. of coal for the block (excluding the area where it is presumably burnt) would be over 35 million tons.

Just underlying the 30-ft. seam is the 13-ft. 3 in. seam struck at 238 ft. 4 in. in the No. 9 borehole and appears to be the same as the 10-ft. 6 in. seam at 185 ft. 3 in. in the Pundi borehole No. 1. This very seam is met with in Barughutu drift No. 9 where it shows an ash content of 24·50 per cent. which is rather too high. No other seam has been proved in the No. 9 borehole but the Pundi borehole has cut through another 14-ft. seam at 226 ft. 6 in. On analysis of the core samples the ash content is found to be 28·85 per cent. The two coal seams occurring below the thick seam, if properly washed, would give the requisite type

of coal which would come to about 25 milion tons on the basis of 10 ft. of coal for the whole block.

The 11 seam does not appear to be of good quality and moreover it contains numerous shale and other useless bands and is not found throughout the block. The section of good coal varying in thickness from 3 ft. 9 in. to 6 ft. 6 in. and in ash content from 15·9 to 17·1 per cent. and lying below the 11 seam is apparently present in over half the block. Assuming an average thickness of 4 ft. of coal for this section an additional six million tons would be found in this block.

Basaudi Block

The Basaudi Block is situated to the contiguous west of the Pundi Block in the downthrow side of the south-westerly continuation of the Banji fault. The eastern and southern boundaries of this block have been fixed by the Banji and Hesagara faults respectively while the northern and western ones have been taken as the latitude and longitude of Keke Basaudi (23°48′ : 85°30′).

The area is occupied by rocks of the Barakar stage and the only outcrop of coal found lies north of Pundi (23°46½′ : 85°31½′). The sandstones, which are sometimes gritty, are dipping south-west at nearly 30°. The block apparently (as judged from surface evidence) is not traversed by any fault ; the continuation of the fault southwest of Barughutu Trial shaft No. 6 seen at the top east corner practically coincides with its northern boundary.

Pundi drift No. 2 was made in the coal outcrop north of Pundi. The following is the section of the coal seam sampled together with the proximate analysis :—

Pundi Drift No 2.

Section.	Thickness. Ft.	In.	
SHALY SANDSTONE ROOF.			
Decomposed stuff	5	0	Not included in the sample.
Shale . . .	0	6	
Coal . . .	0	6	
Shale . . .	1	0	
Coal . . .	0	4	
Ferruginous band .	0	4	
Coal . . .	0	4	
Ferruginous band .	0	2	Not included in the sample.
Coal . . .	0	8	
Ferruginous band .	0	4	
Coal . . .	0	2	
Shale .	2	0	

Pundi Drift No. 2—contd.

Section. SHALY SANDSTONE ROOF.	Thickness Ft.	In.	
Coal . . .	0	2	
Bony Coal . .	0	4	
Shaly Coal . .	1	5	
Shale . . .	0	2	
Coal . . .	1	0	
Bony band . .	0	1	14 ft. 2 in. All bands other than those of coal excluded in sample for analysis.
Coal . . .	0	2	
Bony band . .	0	3	
Coal . .	0	7	
Shaly coal . .	0	10	
Coal . . .	0	6	
Shale . . .	0	1	
Coal . . .	0	4	
Shale . . .	3	2	
Bony band .	1	0	
Shale . . .	0	1	
Bony band . .	1	0	
Shale . . .	0	1	
Bony band . .	1	0	
Coal . . .	0	6	
Bony band . .	0	6	
Coal . .	0	8	
Bony band . .	1	0	
Shaly coal . .	0	5	
Coal . . .	0	10	
Shaly coal . .	0	6	
Coal . . .	0	8	
	29	8	

Rejection of bands—8 ft. 11 in., *i.e.*, 62·94 per cent.

Proximate analysis :—

	Per cent.	
Moisture . .	2·50	
Volatiles . .	26·70	Calorific value of the coal—6,420 calories.
Ash . .	20·80	
Fixed Carbon .	50·00	Nature of the coal—Coking.
	100·00	Colour of the ash—Grey.

From the stratigraphic position and the analysis it is concluded that the coal belongs to the 11 seam. The lower seams from 10 seam downwards may be reasonably expected to underlie this block, but this requires to be proved.

The West Bokaro colliery area includes Blocks B (North and South and A). The colliery was started in 1948, the proprietors being Tata Iron and Steel Company while the Managing Agents in the beginning were Messrs. Anderson, Wright & Co. Underground mining is being carried out. The colliery embraces one of the biggest compact unit for development of a modern enterprise. The property extends over an area of 15 sq. miles of coal-bearing land.

The coal of the West Bokaro colliery area, although with a slightly high ash content, was proved amenable to washing up to the state it could be made into a good coke suitable for metallurgical purposes. For this purpose the first coal washing plant in India has been installed there. A 135 ton/hour Chance Coal Washing plant is in operation. The colliery had been generating its own power.

For underground development and transport coal cutting machin e and diesel locomotives are in use.

The method of mining followed is mechanised American Room and Pillar method with its consequent advantage of higher output per man shift. The colliery had already taken shape by 1951 and was producing about 15,000 tons of coal per month from development headings and it was anticipated then that the output would reach a figure of over 40,000 tons per month in about a year from that time. Indeed, West Bokaro colliery area had already grown by 1951 into a little township, where tigers used to prowl in thick forest only three years before.

Kuju-Hesagara area

The Kuju-Hesagara area extends northwards from Kuju village (23°43½′ : 85°30¼′) up to the latitude of mile 20 on the Hazaribagh-Ranchi road, to the east up to Dumarbera (23°45′: 85°32′) and westwards as far as Banwar (23°44½′ : 85°29½′). This area has been divided into

three blocks—one south (Kuju Block) and another north (Hesagara Block) of the Duni fault which crosses the Hazaribagh-Ranchi road at mile 21/3, just north of the road bridge over the Chotha *nadi*. A third block (Murpa Block) has been made out east of the Kuju Block, north of Murpa (23°44′ : 85°31′).

The geological formations met with in this area are—the Archaeans, Barakar rocks, Barren Measures and the Intrusive igneous rocks. The Archaeans are cropping out in the southern part of the area continuing from south of Kuju up to almost milestone 23 on the motor road. They are again found just north of the Hesagara fault (a branch of the Duni fault) north of milestone 20 on the same road. The rocks chiefly comprise granitoid gneisses and mica-schists traversed by pegmatitic and quartz veins. These rocks are overlain by the Barakars, found in the eastern part, consisting of sandstones, sometimes conglomeratic in nature, shaly sandstones and shales, usually carbonaceous and occasionally ferruginous with interbedded seams of coal. The Archaean-Barakar boundary here is presumably a faulted one. Overlying the Barakar rocks the Barren Measures are exposed in the western portion of the area and consist of carbonaceous shales containing concretions of impure iron-ores, and slightly brownish sandy shales. The Barakar-Barren Measures boundary is generally obscured by a soil cover.

A mica-peridotite dyke has been found in the east-central portion of the area running across the Chotha *nadi* in a W.N.W.—E.S.E. direction.

Five boreholes had been put down by Messrs. Anderson, Wright & Co. on behalf of the Bokaro and Ramgur Ltd. at different places in this area. These are Banwar borehole No. 1 and Chotha boreholes Nos. 1-4. The coal seams met with in each borehole are shown in section in Plate XI.

Kuju Block (Block G of the Company)

Kuju Seam.

The Kuju Block lies north of Kuju (23°43¼′ : 85°30¼′) on both sides of the Hazaribagh-Ranchi road from mile 23/1 to just north of the road bridge on the Chotha *nadi* at mile 24/4. It has for its eastern boundary the Bandarchua *nala* and the N.W.—S.E. fault passing through the *nala* about two furlongs from its junction with the Chotha *nadi*. On the north and north-east it is bounded by the south-western continuation of the Duni fault and on the south by the Banwar fault and the Archaean rocks. Excepting a minor fault in the Chotha *nadi* east of the road bridge this block is not affected by any faults.

In the Bandarchua *nala* a coal seam, the Kuju seam, is exposed for nearly 1,000 yards a little over a mile north of Kuju. The seam has two portions, top and bottom, separated by a parting of sandstone varying from 3 ft. to over 4 ft. near the southern extremity till it almost vanishes towards the northern end. The dip of the seam varies from W.S.W. to W.N.W. the amount being 15°. The thicknesses of the seam are 12 ft. 6 in. and 23 ft. 7 in. in the upper and lower sections respectively. In the Chotha *nadi* in the portion between its junction with the Bandarchua *nala* and the road bridge two coal seams above the Kuju seam are cropping out. The topmost seam, the Banwar seam, is exposed in the Banwar *nala* east of Banwar (23°44½′ : 85°29½′) and cut off by the Banwar fault.

From the direction and amount of dip the Kuju Seam is expected to occur at a depth of nearly 400 ft. at the Duni fault. It has often been observed that there is a tendency for the beds to flatten out at depths and therefore the Kuju seam may reasonably be expected to occur at a depth of less than 400 ft. from the surface. This has been proved to be so from the records of the Chotha borehole No. 1 (just south-east of the road bridge on the Chotha *nadi*) wherein the Kuju seam is struck at a depth of 320 ft. 6 in. Three seams have been met with in this borehole above the Kuju seam and these are as follows :

10 ft. 0 in. seam at 47 ft. 6 in. from the surface

4 ft. 6 in. seam at 144 ft. 6 in. ,, ,, ,,

27 ft. 6 in. seam at 217 ft. 0 in. ,, ,, ,,

In the same borehole two other coal seams have been cut through below the Kuju seam and they are

10 ft. 11½ in. seam at 442 ft. 0 in. from the surface, and

11 ft. 0 in. seam at 662 ft. 0 in. ,, ,, ,,

This borehole, however, has not met the topmost Banwar seam as the latter does not occur at this site.

On the north of the Duni fault Chotha boreholes Nos. 2 and 4 and south of the fault in the Kuju block, Chotha borehole No. 3 and Banwar borehole No. 1 were put down. Chotha borehole No. 2 was put down east of Kasikhap (23°45′ : 85°30′) and it proved the existence of the following coal seams :—

		Per cent.
8 ft. 0 in. seam at a depth of 330 ft. 6 in.	Ash . .	28·83
10 ft. 7 in. seam at a depth of 383 ft. 0 in.		
7 ft. 0 in. seam at a depth of 457 ft. 6 in.	Ash . .	33·48 (excluding 1 ft. 6 in. Shale bands).
29 ft. 0 in. seam at a depth of 476 ft. 0 in.	Ash . .	17·61 (from analysis of 8 ft. 4 in. Section at the bottom).
9 ft. 0 in. seam at a depth of 591 ft. 0 in.	Ash . .	24·67

In the Chotha borehole No. 3, a 9 ft. 11 in. seam was met with at a depth of 284 ft. and this on analysis gave 28·48 per cent. ash. This is the same as the 8 ft. seam met with in Chotha borehole No. 2 at 330 ft. 6 in. Unfortunately the No. 3 boring was stopped after it had reached a depth of 335 ft. ; otherwise it would have passed through all the other seams including the Kuju seam.

The Banwar borehole No. 1 proved the following seams :—

9 ft. 0 in.	seam at	9 ft.
4 ft. 6 in.	,, ,,	39 ft.
17 ft. 0 in.	,, ,,	154 ft.
8 ft. 3 in.	,, ,,	287 ft.

The total depth of the hole was 473 feet, but it struck the metamorphics (Archaeans) at 413 ft. without proving the Kuju seam.

From the borehole records it will be seen that the Barren Measures are not very thick at the sites of the Chotha borehole Nos. 2 and 3 in which the Barakar rocks were met with at depths of 322 ft. and 284 ft. respectively.

The following analyses of the Kuju seam are given by Dr. C. S. Fox (1934, pp. 132-133) :—

	Top Nine feet.	Bottom Nine feet.
	Per cent.	Per cent.
Moisture	3·65	2·45
Volatile matter . .	25·90	24·20
Ash	13·10	19·70
Fixed Carbon . . .	57·35	53·65
	100·00	100·00
Calorific value	6,820 calories	6,525 calories.
Caking property	Non-caking	Non-caking.

About the Kuju seam, Dr. Fox says—" These analyses suggest that the coals should be of caking quality, and information in regard to other samples shows that in some cases the coal is of caking quality. However, until the history of the samples and the method of ascertaining the caking property are given, it is not possible to say definitely that a coal of such compostion as that of the Kuju seam is of non-caking quality. "

In 1938-39 the Company, to prove the quality, put down three drifts in the Kuju seam in the Bandrachua *nala*. The seam has been divided

into two sections, top and bottom. The following are the details of sections with the analyses of the coal :—

Kuju No. 1 Drift.

Section.

SHALY SANDSTONE ROOF.

All bands other than those of coal excluded in sample for analysis.

Ft.	In.		
0	10	Bony coal.	
1	8	Coal . . .	Ash 15·89%
0	2	Shale.	
0	7	Coal . . .	Ash 10·94% (7 ft. 0 in. – 0 ft. 7 in. bands)
0	1	Bony coal . .	
0	9	Coal . . .	
0	3	Bony coal . .	
0	7	Coal . . .	
0	2½	Bony coal.	
2	0	Coal . . .	Ash 13·50%
0	1	Shale.	
0	7	Coal . . .	Ash 12·77 %
0	4	Bony coal . .	
0	6	Coal . .	
0	3	Bony coal . .	
0	5	Coal . . .	
0	4	Bony coal . .	
0	9	Coal . . .	
0	2	Bony coal.	
0	11	Coal . . .	Ash 18·45%
2	0	Coal . . .	
0	6	Shale . .	
2	0	Coal . . .	
0	2	Ironstone . .	
5	1	Coal . . .	
0	2	Ironstone . .	
3	9	Coal . . .	
2	0	Shale coal . .	

Analysis.

Top—10 ft. 7½ in.

	Per cent.
Moisture .	2·10
Volatiles .	30·00
Ash . .	13·10
F. Carbon .	54·80
	100·00

Calorific value of the coal—7,120 calories.

Bands excluded—9 bands totalling 1 ft. 10 in., *i.e.*, 17·32 per cent.

Bottom—13 ft. 8 in.

	Per cent.
Moisture .	1·90
Volatiles .	28·25
Ash . .	18·45
F. Carbon .	51·40
	100·00

Bands excluded—3 bands totalling 10 in., *i.e.*, 6·09 per cent.

Kuju No. 2 Drift

Section.

Ft	In			Analysis.	Per cent.
0	4	Shaly Coal.			
2	0	Coal . . .	Ash 18·36%		
0	3	Shale.			
4	0	Coal . . .	2 bands of bony coal 2 & 3 included.	Ash . .	13·54
2	8	Coal . . .	2 band of bony coal included.	Ash . .	15·2
2	9	Coal . . .	Ash 14·65% (Coal, Bony coal, Coal)		
0	2	Bony coal . .			
0	6	Coal . . .			
0	6	Shale . .			
0	3	Shale . .			
2	0	Coal . . .	Ash 19·15%		
0	2	Ironstone.			
2	0	Coal . . .	Ash 16·6%		
2	10	Coal . . .	Ash 19·58%		
0	2	Ironstone.			
4	0	Coal . . .	Ash 19·16%		

Analysis.

Top—12 ft. 4 in.

	Per cent.
Moisture .	1·54
Volatiles .	30·36
Ash . .	14·91
F. Carbon .	53·19
	100.00

Calorific value 6,890 calories.

Bands excluded form 4·48%.

Bottom—11 ft. 2 in.

	Per cent.
Ash . .	18·80

Bands excluded form 5·77.

Kuju No. 3 Drift

Section.

SHALY SANDSTONE ROOF.

Ft.	In.		
1	1	Shaly coal.	Top 11 ft. 9 in. leaving 1 ft. 1 in. in roof.
1	9	Coal. . .	Ash 15·25%
0	4	Ironstone.	
1	2	Coal . . .	Ash 11·49%
0	4	Bony Coal.	
0	6	Coal.	
0	2	Bony Coal.	
1	6	Coal . . .	Ash 12·85%
0	2	Shale.	Bottom 8′-0″ leaving 1′-6″ in floor.
1	6	Coal.	
0	4	Bony coal.	
4	0	Coal . . .	Ash 12·9%
2	0	Shaly and Bony coal.	
1	9	Coal . . .	Ash 13·2%
0	6	Ironstone.	
2	10	Coal . . .	Ash 11·54%
0	7	Ironstone.	
3	2	Coal . . .	Ash 17·0%
1	6	Shaly coal.	

All bands other than those of coal excluded in sample for analysis.

Analysis.

	Per cent.
Moisture .	2·70
Volatiles .	28·27
Ash . .	12·60
F. Carbon .	56·63
	100·00
Calorific value	7,322 calories.
Bands excluded	11·24%

	Per cent.
Moisture .	2·83
Volatiles .	28·21
Ash .	14·14
F. Carbon .	54.83
Calorific value	7,150 calories.
Bands excluded	12·26%

For the purpose of checking the previous sections and analyses as also for determining the caking properties the old drifts were re-opened. The subsequent results of analyses are as follows :

Kuju Drift No. 1.

Top Section.

Proximate Analysis :—	Per cent.
Moisture	5·60
Volatiles	29·65
Ash	11·28
Fixed Carbon	53·47
	100·00

Calorific value of the coal	6,940 calories.
Nature of the coal	Caking.
Colour of the ash	Grey to white.

Bottom Section.

	Per cent.
Moisture	4·70
Volatiles	28·35
Ash	14·60
Fixed Carbon	52·35
	100·00

Calorific value of the coal	6,725 calories.
Colour of the ash	White to grey.
Nature of the coal	Coking.

Kuju Drift No. 3.

Proximate analysis :—	Per cent.
Moisture	6·80
Volatiles	29·65
Ash	11·00
Fixed Carbon	52·55
	100·00

Calorific value	6,820 calories.
Nature of the coal	Coking.
Colour of the ash	Grey to white.

In addition to these a new drift (No. 1A) was made close to the No. 1 Drift, just above the sandstone band on the top of the Kuju Seam. A sample from the section given below has been analysed with the following results :—

No 1A Kuju Drift

Section.

SHALY SANDSTONE ROOF

Ft.	In.	
0	6	Coal. } Not included in sample.
0	4	Shale. }
0	2	Shaly coal.
1	0	Shale.
1	3	Shaly coal.
1	0	Shale.
1	3	Shaly coal.
0	6	Coal.
0	1	Ferruginous band.
0	3	Coal.
0	6	Laminated shale band.
0	5	Coal.
0	6	Laminated shale band.
0	4	Coal.
0	4	Shale.
2	0	Hard coal.
0	2	Bony coal.
0	7	Coal.
0	7	Ferruginous band.
0	6	Coal.
0	8	Bony coal.
0	6	Coal.
2	3	Shaly sandstone.

Analysis.

	Per cent.
Moisture . .	4·50
Volatiles . .	27·45
Ash . . .	22·20
Fixed Carbon .	45·85
	100·00

All bands excluding those of coal excluded in samples for analysis.

In No. 1 Drift the Kuju seam is underlain by a 2 ft. 6 in. thick coal seam separated from the former by a sandstone parting of 2 ft. 10 in. No samples, however, were collected from this thin seam. In the beginning of the year 1948 the area was revisited and the Kuju seam was sampled again in the quarry then existing. The thicknesses of the seam, as will appear from the following section, are 12 ft. 6 in. and 23 ft. 7 in. in the upper and the lower sections, respectively :—

Section of the Kuju seam :—

Thickness. Ft.	In.		Ash. Per cent.
		CARBONACEOUS SHALE ROOF	
0	5	Slickensided coal	15·18
1	8	Shaly coal	55·04
4	3	Coal (including one ½" *matti* band).	
0	5	Shale band	23·92
3	4	Coal	26·24
0	9	*Matti* band	20·54
1	8	Coal.	
12	6		
4	3	Sandstone with carbonaceous shale at top.	
7	2	Coal	17·74
0	3	Soft and *matti* band.	
2	2	Coal	20·44
0	3	Shaly band.	
3	0	Coal	15·38
0	4½	Shale band.	
2	1	Coal	14·46
0	5½	Soft and *matti* band.	
	10	Coal	24·54
0	4	Oolitic ferruginous and *matti* band.	
4	8	Coal	19·66
27	10		
		CARBONACEOUS SHALE FLOOR	

The following is the proximate analysis of the average sample (top and bottom seams together) excluding all shale and *matti* bands :—

	Per cent.
Moisture	4·62
Volatiles	26·70
Ash	22·92
Fixed Carbon	45·76
	100·00

Calorific value of the coal	5,985 calories or 10,773 B. t. u.
Nature of the coal	Caking (non-swelling).
Colour of the ash	Grey.

The Kuju seam, as already stated has been, divided into top and bottom sections, separated by a band of shaly and bony coal. The Kuju coal is of caking quality ; the coke formed is quite hard and has got high crushing strength but has got some prominent fissures along which it breaks up easily under pressure. The Kuju coal belongs to the high volatile and high moisture group, similar to those of the Raniganj coalfield as found in its western part.

The coke-buttons formed by the Kuju coals are always lean and dense and have got prominent fissure-cracks along which the coke breaks into smaller bits under pressure.

The 'Top Kargali' and Barughutu No. 10 seams yield rather fat and strongly bound button. Owing to the excessive spongy nature of the Top Kargali coke, the coke button is rather weak under crushing force, whereas the Kuju coke button being dense in structure stands a much higher degree of crushing force. But in actual practice, as we know, the Top Kargali seam either in modern battery or in country oven makes an ideal dense and hard metallurgical coke.

The binding power of Kuju coal was also tested with fine sand and it was found that the top Kargali seam has got a little higher binding capacity than the Kuju samples.

According to S. Roy Illingworth—"from Coke oven practice it may be stated as a broad generalisation that coals which belong to the Ortho-Bituminous series and which yield under 22—32% of volatile matter at 900°C calculated to the ash free dry basis, give rise to satisfactory coke, but that if the volatile matter be above this figure the charge requires to be compressed before carbonisation". Therefore unless the Kuju coals are actually tested in coke oven it is not wise to draw a final conclusion from the laboratory results only.

It would thus be seen that the quality of the Kuju seam and especially of the top section is very good, and that on an average a thickness of 20 feet coal will be available; but in every case hand-picking would be necessary to exclude shale and bony coal bands. Although the coke-buttons

formed by the Kuju coal are not highly satisfactory, an ideal hard coke could be obtained by blending the Kuju coal with another suitable coal. As the ash content is in itself very low it does not appear necessary to wash this coal. Hand-picking on a belt will yield a satisfactory grade. If at any time it becomes necessary to further reduce its ash content washability tests may be carried out with the Kuju coal.

As regards other coal seams in this block, they are undoubtedly inferior to the Kuju seam. It is suggested that washability tests be carried out to reduce their ash percentage. The Banwar seam occupies only a small area in the western corner of the block and on account of its rather poor quality and the predominance of shale and bony coal bands it does not require much attention.

The structure of the block is simple—the seams are resting one above the other and dipping in a general north-westerly direction.

The total area covered by the Kuju seam is nearly 1,100 bighas and even if only the 20 ft. thickness of the Kuju seam is worked the area appears to be a promising one. The quantity of coal *in situ* will be 11 million tons roughly.

The reserves of the Kuju seam in terms of quarriable coals have been calculated as follows :

638,100 tons with overburden equal to the thickness of the Seam.
1,276,200 tons ,, ,, twice ,, ,, ,,
1,906,300 tons ,, ,, thrice ,, ,, ,,

If the other seams could be properly washed an additional thickness of at least 50 feet coal over an area of nearly 850 bighas would be available. This would yield 21·25 million tons approximately.

Banwar Seam.

The topmost seam in the Kuju block is the Banwar seam which is cropping out east of Banwar and worked in the Banwar Colliery. It has a thickness of about 35 ft. It dips N.N.W. at 12°. At the western end of the outcrop the overburden has been burnt without any appreciable damage to the underlying coal. The seam is cut off on the south by a fault running S. 80°E.—N. 80°W. The following section of the seam, on analysis, yields the results as given below :—

Thickness. Ft.	In.		Ash. Per cent.
		SANDSTONE ROOF	
0	6	Carbonaceous shale	31·54
1	9	Coal	25·54
2	2	Shaly coal	54·64
0	4	Slickensided coal	20·30

Thickness. Ft.	In.	SANDSTONE ROOF	Ash Per cent.
1	0	Shaly coal	55·36
5	0	Coal	28·20
1	0	Shale	64·98
0	9	Coal	24·50
0	4	*Matti* band	20·98
7	5	Coal	21·72
0	3	Shale	75·00
9	4	Coal	21·58
0	3	Slickensided coal	13·12
1	0	Coal	24·52
0	9	*Matti* band	29·12
6	0	Coal	18·28

(Section incomplete, floor not exposed due to water trouble.)

Proximate analysis of the average sample is :—

	By G.S.I. Per cent.	By F.R.I. Per cent.
Moisture	3·80	2·60
Volatiles	28·05	26·20
Ash	26·64	29·50
Fixed Carbon	41·51	41·70
	100·00	100·00

Calorific value of the coal	9,470 B. t. u.
Nature of the coal	Caking (slightly swelling).
Colour of the ash	Grey.

No samples were taken from the coal seams cropping out in the Chotha *nadi*.

The reserves of coal from the Banwar seam are given below :

165,400 tons with overburden equal to the thickness of the Seam.

330,800 tons ,, ,, twice ,, ,, ,,

496,200 tons ,, ,, thrice ,, ,, ,,

Hesagara Block

This block lies to the adjacent north of the Kuju block on the northern and downthrow side of the Duni fault. It occupies the triangular area formed by the Duni fault and another fault, *viz.*, the Hesagara fault, branching off from it in an almost east-west direction crossing the Hazaribagh-Ranchi Road close to milestone 20. Thus, the north, east and southern boundaries are formed by the two faults; the western boundary has been kept open.

In the Chapa *nala*, which meets the Chotha *nadi* just east of the road bridge, four outcrops of coal are met with as one proceeds upstream from its junction with the Chotha *nadi*. Of these one is on the north of Hesagara fault and might be only the continuation of the one immediately south of it. From the dip of the strata the country appears to be slightly folded. Several faults in different directions could be seen in the *nala* and these have disturbed the strata including the coal out crops. "Burnt outcrops" are noticed east of Hesagara village (23°45½′ : 85°33½′).

Two boreholes, namely, the Chotha boreholes Nos. 2 and 4, had been put down in this area. In No. 2 borehole a seam with a good section of 8 ft. 4 in. at the bottom and having an ash content of 17·61% was struck below 476 ft. In the Chotha borehole No. 4, the following seams have been met with :—

8 ft. 7 in.	seam at	19 ft. 9 in.	
5 ft. 10 in.	,, ,,	86 ft. 0 in.	Ash 21·15 per cent.
21 ft. 8 in.	,, ,,	124 ft. 0 in.	Analysis of top 6 ft. 10 in. of seam at 130 ft. omitting 2 in., 1 ft. and 4 in. bands gave 21·15 per cent. ash.
5 ft. 9 in.	,, ,,	250 ft. 6 in.	
3 ft. 6 in.	,, ,,	285 ft. 6 in.	
4 ft. 0 in.	,, ,,	299 ft. 0 in.	
8 ft. 7 in.	,, ,,	304 ft. 5 in.	Ash 18 ·37 per cent.

The total depth of this hole was 364 ft. The Ironstone shales are not thick at this borehole site, the top of the Barakars having been encountered, as is reported, at a depth of only 18 ft. 6 in. The 8 ft. 7 in. seam at 304 ft. 5 in. appears to be the same as the 8 ft. 4 in. section below 476 ft. in the No. 2 borehole.

It was previously thought, from the consideration of the fact that the Ironstone shales are not very thick in this block, at least in the eastern portion that this might open out a very valuable area. Boring reports, however, do not confirm that view. The only coal, as it is, that is workable appears to be the 8 ft. 4 in. section of the seam lying at a depth of from 300 to 500 ft., which from the analysis of the borehole cores, shows an ash percentage in the neighbourhood of 18. But as the analysis of the borehole cores always shows a higher ash percentage the actual ash content might be near about 16%. The total quantity of the good coal has not been calculated as the lateral extent of the seam is not known. If the coals could be washed economically this block would produce a much greater quantity of coal.

The coal outcrops in the Chapa *nala* do not deserve much attention, as they do not appear to be of good quality and also due to the fact that these outcrops are much affected by faulting.

The Hesagara seam crops out about a furlong N.N.E. of Hesagara village and dips west to W.N.W. at 5°. The thickness of the seam, as appears from the following section, is 25 feet :—

Section of the seam sampled :—

	Description.	Thickness. Ft.	In.	Ash. Per cent.
ROOF	Sandstone 1′ to 2′	..		..
	Carbonaceous shale 9″	..		..
	Shale with *matti* band*	5	6	55·92
	Coal	4	0	37·70
	Shale*	0	3	62·40
	Coal	5	2	23·54
	Matti band*	0	4	37·32
	Coal	2	6	36·28
	Carbonaceous shale*	1	3	35·92
	Coal	3	6	32·38
	Carbonaceous shale*	1	0	36·38
	Coal	1	6	31·54
CARBONACEOUS SHALE FLOOR	Total	25	0	

The proximate analysis of the average sample excluding all bands marked * is :—

	By G.S.I. Per cent.	By F.R.I. Per cent.
Moisture	3·65	2·50
Ash	37·16	40·10
Volatiles	26·45	24·20
Fixed Carbon	32·74	33·20
	100·00	100·00

Calorific value of the coal	7,800 B.t.u.
Nature of the coal	Caking (slightly swelling).
Colour of the ash	Pinkish grey.

The reserves of the coal are as follows :

67,510 tons with overburden equal to the thickness of the Seam.
135,020 tons ,, ,, twice ,, ,, ,,
202,530 tons ,, ,, thrice ,, ,, ,,
2,700,400 tons down to 1,000 ft. depth.

Murpa Block

(Block S of the Company, east of Kuju Block)

This block commences from about six furlongs north of Murpa (23°43½′: 85°31′) and is situated east of the Kuju Block. The rocks here consist of the Barakars and just north of the Archaean-Barakar boundary a coal seam (Murpa seam) is cropping out in the stream meeting Madhiachatan *nala*. The total length of this outcrop is nearly 1,000 feet. No other coal outcrop has been found in this block. The general direction of the dip of the rocks is north-westerly, the amount varying from 20° to 25°. A Trial Pit was made in previous years to determine the quality of the seam, but unfortunately no records are available. An attempt has been made to drive a drift (Murpa drift) into the western part of this seam for exposing a section from which samples could be taken for analysis. At the top decomposed stuff was obtained; this was followed by broken coal. At first it was thought that the quality of the coal would improve at depth. This, however, did not prove to be so, as after going to a depth of nearly 20 feet, the coal was found to be very much disturbed and mixed up with pieces of carbonaceous shale. Here the seam is dipping north at 40° but in depth the dip appears to increase to 55°. The bottom of the seam was not reached and as there was no hope of exposing a full undisturbed section from which a sample for analysis could be obtained in the short time available, the drift was finally closed (on 30-9-42).

A Trial pit was made in this seam close to the Madhiachatan *nala*. It did not, however, expose the full section, as the top portion had been denuded away. The results of analysis of a sample from this pit are as follows:

Murpa Trial pit

The section of the seam :—

Ft.	In.	DECOMPOSED STUFF (COAL AND SHALES) LEFT IN THE ROOF	
0	9	. . . . .	Soft stuff not included in the sample.
0	3	Bony coal band . .	
			Analysis.
1	0	Coal . . .	Ash 24·35 per cent., Moisture 5·60 per cent. Volatile 24·80 per cent.
0	2	Shale.* . . .	
0	11	Coal . . .	Very poor coke, almost non-coking.
0	4	Bony coal* . .	Ash—18·50 per cent., Moisture 3·20 per cent., Volatile 28·25 per cent.
5	8	Coal	Coking coal, coke wit I lead-grey lustre.
9	1	SHALE FLOOR	

NOTE.—The bands marked with* are not included in the sample.

Leaving out the soft and decomposed stuff in the roof, the height of the seam included in the sample is 8 ft. 1 in. only and out of this 0 ft. 6 in. of shale and bony coal bands were rejected. Hence the total rejection of the section sampled is 6·20 per cent. approximately.

	Per cent.	
Moisture	4·00	Calorific value of the coal—6,330 calories.
Volatiles	26·70	
Ash	20·20	Nature of the coal—Coking.
Fixed Carbon . . .	49·10	Colour of the ash—White with a faint buff tint.
	100·00	

The coal seam in the pit dips north-west at 15°.

The high dips of the Murpa seam suggest that it is close to some fault. Moreover, the crumpled nature of the coal leads one to the conclusion that this seam is affected by faults. It is likely that movements have taken place at or close to the Archaean boundary. The area to which the Murpa seam extends in a northerly direction could not be determined, as no boreholes have been put down.

From the analyses it would appear that a 5 ft. 8 in. section at the bottom of the seam shows an ash percentage of 18·50 and is of caking quality. It is, therefore, suggested that the extent of the Murpa seam be proved by putting down boreholes in the country north of the outcrop.

The Murpa seam crops out north of Nowadip (23°44′ : 85°31′) and is considered to be probably to the continuation of the Kuju seam brought into its present position by the N. W.—S. E. fault at its western end. Here the outcrop could be traced for a distance of over 1,000 feet. The seam is dipping north-west at 15°, although close to the fault the dip is as high as 45°. The seam is 35 feet thick as will appear from the following section sampled at the Murpa colliery and the average sample (after excluding all bands other than those of coal), on analysis, gives the following results :—

Description.	Thickness. Ft.	In.	Ash. Per cent.
SANDSTONE ROOF			
Coal	6	8	34·80
Shale	1	4	63·50
Coal	5	2	23·74
Matti band	0	3	21·66
Coal	3	6	29·30
Matti band	0	2	21·70
Coal	2	10	21·60
Matti band	0	3	15·16
Coal	9	1	18·54
Coal, bright	0	9	15·30
Coal	5	0	25·08
CARBONACEOUS SHALE FLOOR Total .	35	0	

Proximate analysis :—

	By G.S.I. Per cent.	By F.R.I. Per cent.
Moisture	3·40	2·80
Ash	26·40	26·90
Volatiles	27·17	26·20
Fixed Carbon . . .	43·03	44·10
	100·00	100·00

Calorific value of the coal . . . . 9,830 B.t.u.

Nature of the coal . . . . . . Caking (slightly swelling).

Colour of the ash . . . . . . Buff.

The quantity of coal available from this seam is given below :

35,450 tons with overburden equal to the thickness of the Seam.

70,900 tons „ „ twice „ „ „

106,350 tons „ „ thrice „ „ „

1,063,500 tons down to a depth of 1,000 feet.

Dumarbera-Ara-Chainpur Area

(Containing Dumarbera-Ara Block)

The Dumarbera-Ara-Chainpur area lies to the east of the Kuju-Hesagara area and is bounded on the east and west by the longitudes of Bhadwa (23°44′ : 85°35′) and Dumarbera (23°45′ : 85°32′), respectively. On the north it extends as far as the Bokaro river and the Chotha *nadi* and on the south up to the latitude of Kundri (23° 43′ : 85° 32½′).

The Archaeans and the Barakars are found in this block. The Archaeans consist of a variety of rocks comprising chiefly granitoid gneisses and mica-schists traversed by pegmatitic and quartz veins. At several places granulites, sometimes having a schistose structure, are found. The Barakars are represented mainly by sandstones, generally coarse-grained and often conglomeratic in texture, and shales, both carbonaceous and slightly ferruginous. The conglomeratic sandstones occasionally approach true conglomerates and contain quartz pebbles of different sizes and colours. The pebbles vary from the size of a walnut to that of a big boulder. Their colour is generally white to light greyish though brownish varieties are not rare. Interbedded with the sandstones and shales are seams of coal, outcrops of which have been noted at several places. Two fairly big outcrops of coal, one above the other, are seen east of Dumarbera in the Karijhoua *nala* and it is for these two seams that the Dumarbera-Ara area has been blocked out.

In the Bokaro river at its junction with the Chotha *nadi* two outcrops of coal separated by carbonaceous shales are found. Of these two seams the bottom one is nearly 20 ft. thick, while the other is 10 ft. to 12 ft. The seams are dipping north to north-north-east at 25° and could be traced in the Bokaro river near its junction with Karijhoua *nala*, west of Sarubera (23° 46′ : 85° 33′). In the acute bend of the Bokaro river north-east of Sarubera, two coal seams are seen dipping N. 10° E. at 55°. Eastwards two other coal outcrops are noted in this river. These are dipping north-west at 25°. Finally, at its junction with the Jharna *nala* another coal outcrop is found south of Block A dipping north-west at about 25°.

Several other outcrops of coal are noticed in the stream meeting the Bokaro river at its acute bend north-east of Sarubera. Of these the coal about a mile south-east of Sarubera was worked for sometime for local consumption. Here the coal is dipping W. N. W. at 20°, but the direction and amount of dip quickly change so that the coal appears to be disturbed. South-south-west of this place there is another outcrop of coal dipping W. N. W. at 5°. The coal appears to be banded with numerous shale partitions and so not much attention need be paid to it.

Along the Bokaro river the dips of the strata are generally high varying from 15° to 60° and it is on account of the high dips that whatever coal is in the neighbourhood, either in the outcrops or underground, will be unsuitable for working on a large scale. The outcrops, however, may be worked by small concerns down to certain convenient depths.

Small inliers of Archaean rocks in the Barakars and outliers of Barakars in the Archaeans are found at some places. Practically the whole of the Barakar country in this area is covered with loose pebbles derived from the conglomeratic sandstones.

Excepting a few minor faults the area is unaffected by any major faulting. Of dykes the eastern end of the mica-peridotite dyke in the Chotha *nadi* north of Dumarbera is just coming into the top western corner. A small aplitic dyke a little outside this area is noted close to the left bank of the Bokaro river E. N. E. of Duni (23° 46′ : 85°33′).

Dumarbera-Ara Block

(Block J of the Company)

The Dumarbera-Ara block is situated east of Dumarbera (23° 45′ : 85° 32′) about a mile north of the Kuju-Chainpur road. The outcrop of the coal seam in the Karijhoua *nala* forms the south-eastern boundary of the block, the south-western boundary of which is up to the Archaean rocks. Its north-eastern boundary is a fault passing through the Karijhoua *nala* in a N.W.—S.E. direction up to which the outcrop could be traced. The Chota *nadi*, west of Ara (23° 46′ : 85° 32½′), may be taken as the north-western boundary of the block where the coal seams will be at a depth of nearly 800 ft. assuming the average amount of dip of the seams to be 10°. The area of the block will be 1,250 bighas.

From previous records it would appear that five boreholes had been put down in this area to prove the extent of the seams. Unfortunately the reports of these boreholes are not available at present. From Mr. E. H. Roberton's report it would appear that he had evidence to say that the seams were struck at the proper depths in boreholes and in the absence of the borehole records these are assumed by the author also. As sufficient information about this block is not possible to obtain from only two drifts made into the two seams the following information from Mr. Roberton's report[1] will be found useful :—

In the Karijhoua *nala* and about 800 ft. to its north two seams of coal are cropping out. The lower seam in the *nala* could be traced up to the fault whereas the upper seam has been burnt in a north-eastern direction and is denoted by the presence of " burnt outcrops " east of Baghal tatoli (23°45′ : 85°33′). Close to the fault in the north-eastern end the lower seam splits up into two, the upper one of which is cropping out in the Karijhoua *nala* itself. The dip of the seam is in a north-westerly direction, the amount being nearly 15° though locally at some places it is N.N.W. at 10° and W.N.W. at 20°. Two drifts have been driven—No. 1 drift into upper seam and No. 2 into the lower seam, respectively. Below is given the section met with in each drift with the corresponding analysis :—

Ara Drifts

Drift No. 1

All bands other than those of coal excluded in sample for analysis. Total thickness—11 ft. 10 in.

Section.			Analysis.	
Ft.	In.	SHALE ROOF		Per cent.
0	11	Coal.	Moisture . .	7·80
0	2	Bony coal.	Volatiles . . .	28·50
1	6	Coal.	Ash	22·75
0	2	Ferruginous band.	Fixed Carbon . .	40·95
				100·00
0	3	Coal.		
0	3	Bony coal.		
0	4	Coal.	Calorific value of the coal—5,680 calories.	
0	2	Bony coal.		
1	3	Coal.		
0	1	Ferruginous band.	Nature of the coal—Non-coking.	
0	1	Coal.		
0	6	Shale.	Colour of the ash—Light pinkish.	

[1] E.H. Roberton, Unpublished report with M/s. Anderson, Wright and Co.

Ara Drifts

Drift No. 1—contd.

Section—*contd.*

Ft.	In.	
0	9	Coal.
0	4	Ferruginous band.
0	6	Coal.
0	6	Shaly coal.
1	8	Coal.
0	4	Ferruginous band.
0	7	Coal.
0	2	Bony coal.
0	4	Ferruginous band.
1	0	Coal.
		SHALE FLOOR

Drift No. 2

Section.

Ft.	In.	SHALE ROOF
1	2	Coal, decomposed stuff.*
1	8	Coal.
0	4	Bony coal bands.*
2	0	Coal.

Analysis.

5 ft. 2 in. thick.

Average rejection—20·03 per cent.

Moisture—1·40 per cent.

Volatile—22·00 per cent.

Fixed Carbon—51·20 per cent.

Ash—25·40 per cent.

Nature of coal—Coking.

0	6	Ferruginous band.*
1	0	Shaly coal.*
0	6	Bony band.

0	7	Coal.
0	3	Bony coal.*

4 ft. 4 in. thick.
Average rejection—9·6 per cent.
Moisture—3·00 per cent.
Volatile—20·80 per cent.

Ara Drifts

Drift No. 2—contd.

Section—*contd.* Ft.	In.		Analysis.
1	2	Coal.	Fixed Carbon—53·40 per cent.
0	1	Bony Coal.*	Ash—22·80.*
1	0	Coal.	Yields poor coke.
0	1	Bony coal.*	
1	2	Coal.	
			6 ft. 9 in. thick.
0	9	Ferruginous band.*	Average rejection—13·58 per cent.
2	2	Coal.	Moisture—6·00 per cent.
0	2	Bony coal bands.*	Volatile—21·00 per cent.
3	8	Coal.	Fixed Carbon—53·80 per cent.
			Ash—19·20 per cent.
0	6	Pyrite.*	Non-coking.
0	6	Coal (not tested).	
19	3		

NOTE.—Bands marked with* are not included in the sample.

The average results of the proximate analysis of the total sample (by mixing 3 samples together in proper proportion), are as follows :

	Per cent.
Moisture	3·20
Volatiles	21·30
Ash	21·95
Fixed Carbon	53·55
	100·00

Colorific value of the coal . . . 6,490 calories.

Nature of the coal . . . . Coking, but it yields very poor coke.

Colour of the ash . . . . Grey with faintly buff tint.

It will be seen from the analyses that the quality of a 6-ft. section at the bottom of the lower seam is the best showing an ash percentage of 19·20.

A hand drill which was used to ascertain the thickness of the coal in the outcrop N.N.E. of drift No. 2 proved a 19-ft. seam. Thus the total thickness of the two seams (lower and upper) would come to about 31 ft.

From Mr. Roberton's report it appears that he had taken the reasonable gross thickness of coal to be 48 ft. Mr. Roberton might have been justified to assume that thickness from the boring reports but as those are not available at present it is difficult to accept that figure. From the available data the total thickness of coal (excluding shale and bony coal bands) appears to be 23 ft. The total coal *in situ* will be 14 million tons roughly.

The main advantage with regard to this block lies in the fact that it is situated within a distance of 1½ mles from the railway line west of Chainpur from where a railway siding could easily be taken to the outcrop. The country over which the siding is to be brought is not a difficult one. Thus one of the main factors, namely, the problem of transport, which usually stands in the way of economical extraction of coal, does not arise in the case of this block.

Dumarbera Seam.

The Dumarbera seam crops out E.S.E. of Parsatoli (23°45′ : 84° 32¼′) and continues in a north-easterly direction for a distance of over 1,500 feet. The seam dips north-west at 10°. The thickness of the seam is in the neighbourhood of 17 ft. as will be seen from the following section sampled : —

Description.	Thickness.	
SANDSTONE (DECOMPOSED) ROOF underlain by Shale	Ft.	In.
Shaly coal	5	0
Carbonaceous shale	0	6
Coal	4	9
Shale	1	0
Matti band	0	4
Coal	6	0
Total	17	7

The proximate analysis of the average sample, excluding all bands other than those of coal, is :—

	By G.S.I.	By F.R.I.
	Per cent.	Per cent.
Moisture . . .	2·50	1·70
Ash	30·78	33·20
Volatiles . . .	23·37	20·20
Fixed Carbon . . .	43·35	44·90
	100·00	100 00

Calorific value of the coal . . . . 9,380 B.t.u.

Nature of the coal . . . . . Coking (slightly swelling).

Colour of the ash . . . . . Pinkish grey.

The reserves of the coal have been calculated as follows :

202,500 tons with overburden equal to the thickness of the Seam.

405,000 tons ,, ,, twice ,, ,, ,,

607,500 tons ,, ,, thrice ,, ,, ,,

13,500,000 tons down to a depth of 1,000 feet.

Ara Seam.

The Ara seam is cropping about north-east of Ara (23°44′ : 85°33½′) and dips N. 10° W. at 12°. The seam, as should appear from the section sampled, is 29 feet 8 inches thick. The section of the seam sampled is given below :

Description.	Thickness.	
SANDSTONE ROOF	Ft.	In.
Carbonaceous shale	1	4
Interbedded lenses of *matti* and soft shale	1	3
Coal (decomposed)	2	0
Matti band	0	4
Coal	4	6
Shale	0	8
Coal	1	5
Carbonaceous shale	0	6
Coal	5	0
Matti band	0	4
Coal	5	0
Matti band	0	4
Coal	7	0
SHALE FLOOR Total .	29	8

The proximate analysis of the average sample of only coal bands in the seam is :—

	By G.S.I.	By F.R.I.
	Per cent.	Per cent.
Moisture	3·52	2·70
Ash	32·62	35·30
Volatiles	19·03	17·60
Fixed Carbon	44·83	44·40
	100·00	100·00

Calorific value of the coal . . .	8,710 B.t.u.
Nature of the coal	Caking (non-swelling).
Colour of the ash	Pinkish grey.

The reserves of coal are as follows :

67,520 tons with overburden equal to the thickness of the Seam.

135,000 tons ,, ,, twice ,, ,, ,,

202,500 tons ,, ,, thrice ,, ,, ,,

2,700,800 tons down to a depth of 1,000 feet.

Datma-Pindra Area

Datma Seam.

The Datma-Pindra area is situated on the Barakar rocks about four miles W.N.W. of Kuju (23°43¼′ : 85°30¼′). At the time of investigation by the author in 1947, two collieries, namely the Datma and the Pindra collieries had been working in the area. In the Datma colliery the Datma seam is cropping out and this was being quarried there. The outcrop of the seam could be traced in a westerly direction to nearly half a mile from the quarry and eastwards nearly two furlongs up to the Topa-Toera cart road. The seam is dipping N.W. to N.N.W.

at 15°. The thickness of the seam is about 31 feet. The section of the seam sampled at the Datma colliery with the proximate analysis is given below :

Description.	Thickness. Ft.	In.	Ash. Per cent.
SANDSTONE ROOF			
Carbonaceous shale	7	0	48·75
Shale	0	9	59·26
Coal	5	0	30·86
Shale	1	6	56·96
Coal	5	0	22·16
Shaly coal	6	6	30·24
Shale	0	6	41·42
Shaly coal	2	6	23·90
Shale	0	6	45·38
Shaly coal	1	10	31·64
CARBONACEOUS SHALE FLOOR Total	31	1	

The proximate analysis of the coal bands (excluding the shale bands) is :—

	By G.S.I. Per cent.	By F.R.I. Per cent.
Moisture	2·27	2·30
Ash	35·00	35·50
Volatiles	23·56	23·90
Fixed carbon	39·17	38·30
	100·00	100·00
Calorific value of the coal	8,730 B.t.u.	
Nature of the coal	Caking (non-swelling).	
Colour of the ash	Pinkish grey.	

The quantity of coal available from this seam is as follows :

506,300 tons with overburden equal to the thickness of the Seam.

1,012,600 tons ,, ,, twice ,, ,, ,,

1,518,900 tons ,, ,, thrice ,, ,, ,,

16,660,000 tons down to a depth of 1,000 feet.

Pindra Seam.

In the Datma-Pindra area the Pindra seam, which just overlies the Datma seam and is separated from the latter by a parting of nearly 140 feet of sandstones, is being worked. This seam has the same direction and amount of dip as those of the Datma seam and is about 12 feet thick. The outcrop of the seam could be traced for a distance of nearly 1,100 yards and at the time of investigation was quarried at the Pindra colliery and also by the Datma colliery at a place west of the former colliery. The following section of the Pindra seam was sampled at the Pindra colliery :—

Description.	Thickness.		Ash.
	Ft.	In.	Per cent.
SANDSTONE ROOF			
Coal	9	0	19·36
Shaly coal	0	6	27·36
Shale	0	2	59 30
Coal	1	0	27·90
Soft shale	0	2	68 20
Coal	1	8	24·06
Total .	12	6	
CARBONACEOUS SHALE FLOOR			

The proximate analysis of the coal excluding all shale bands is given below :

	By G.S.I.	By F.R I.
	Per cent.	Per cent.
Moisture	2·52	2·10
Ash	22·60	23·00
Volatiles	28·49	26·80
Fixed Carbon	46·39	48·10
	100·00	100·00

Calorific value of the coal . . . . . 10,670 B.t.u.

Nature of the coal . . . . Caking (slightly swelling).

Colour of the ash . . . . Grey.

Kedla-Loiyo Area

The Kedla-Loiyo area lies to the east of Blocks B (north) and A separated from both by the Bhalugurha fault and comprises the two blocks Kedla and Loiyo. This area extends north and eastwards as far as the boundary fault and Simra *tungri* (23°47½′ : 85°37½′) respectively, whilst the Bokaro river forms its southern limit.

In 1916-17 Dr. L. L. Fermor examined some of the coal seams near Kedla. These had been previously seen by Mr. R. W. Church and also by Mr. G. Lathbury, but these latter two are said to have held divergent views about them. In 1918-19 this area was examined by borings by Dr. W. Chowdhury on behalf of Bokaro and Ramgur Ltd., and later by Mr. E. R. Roberton. While these investigations were in progress the East Indian and Bengal Nagpur Railways had jointly taken up about 7,600 bighas in this area. Although plans were complete, this area was not worked and later was abandoned.

The area is occupied by the Barakar rocks which show changes in their characters from place to place. The coal seams vary in a similar way, in so far as their thickness and quality are concerned. 'Burnt outcrops' and baked and fused strata are found at several places, for instance, in the hill half a mile S.80°E. of Kedla (23°48′ : 85°35½′) and hills west and S.S.W. of Loiyo (23°47½′ : 85°38½′). Several faults of not very serious consequences are noticed in this area. Due to some cross faults south of Ichakdih (23°48′ : 85°36′), the area has been divided into two blocks—the Kedla Block on the west and the Loiyo Block on the east. The area is traversed by dolerite dykes 10 to 30 ft. in width with an E.N.E.—W.S.W. trend and a mica-peridotite dyke, not more than two to three ft. thick, west of Gose (23°46½′ : 85°36½′). All these must have affected the coal seams to a varying degree, as in one or two instances *jhama* has been noticed.

An examination of the area revealed several outcrops of coal, with varying quality and thickness reaching a maximum of 35½ ft. Several boreholes had been put down in this area and in the adjoining country. The details of the coal seams are shown in section in Plate XI. Several drifts and trial pits (positions shown on the map) have been made in different places in the coal outcrops for proving the sections and obtaining samples for analysis. The following are the details of the sections together with the analytical results :—

Drifts

No. 1 Drift (Kedla)

(Section of the seam cut on 18-4-1944)

Thickness.		Description.	Ash.
Ft.	In.	SANDSTONE ROOF	Per cent.
2	3	Carbonaceous shale	
1	0	Coal	28·60
1	2	Shaly coal*	
1	5	Inferior coal	24·50

Drifts

No. 1 Drift (Kedla)—contd.

Thickness Ft.	In.	Description. SANDSTONE ROOF.	Ash. Per cent.
0	2	Band, shaly.*	
1	8	Coal	24·10
0	2	Bony coal band.*	
0	9	Coal	35·00
0	8	Shaly band.*	
2	7	Coal	18·40
0	2	Band, shaly.*	
1	4	Coal	12·50
0	4	Band.*	
0	10	Coal	21·20
0	4	Band, shaly coal.*	
0	8	Coal	24·70
1	0	Coal	16·30
1	0	Coal	21·60
1	0	Coal	34·80
1	0	Coal	24·80
1	0	Coal	14·30
1	0	Coal	18·00
1	0	Coal	24·60
1	3	Coal	32·20
23	9	SHALE FLOOR	

NOTE.—The bottom 8 ft. 11 in. was exposed in a pit sunk at the mouth of the drift and the coal face being wet, demarcation of bands was rather difficult ; hence foot by foot samples were cut for the bottom 9 ft. section.

The bands marked with* are excluded from the whole sample of the seam 23ft. 9 in. thick, when the total rejection becomes 22·6 per cent. and almost all are in the top part of the seam ; the bottom 9 ft. is clean good coal without any pickable bands whatsoever.

The results of proximate analysis of the whole seam excluding the bands marked* are :—

	Per cent.
Moisture	0·80
Volatiles	21·30
Ash	20·90
Fixed Carbon	57·00
	100·00

Calorific value of the coal	6,820 calories.
Nature of the coal	Coking.
Colour of the Ash	White to light grey.

Drifts

No. 2 Drift (Kedla)

Thickness.		Description.	Ash.
Ft.	In.	INFERIOR COAL ROOF	Per cent.
1	0	Coal	22·00
0	7	Band, shaly.*	
2	3	Coal.	
0	3	Band.*	
4	2	Coal.	
0	8	Band (Shale of variable thickness).	
0	4	Coal.	
0	2	Band.*	
4	3	Coal	24·50
0	5	Band.	
0	7	Coal, bony.	
14	3	SHALE FLOOR	

Another sample was cut from the face of the same drift leaving 1 ft. 3 in. inferior coal at the bottom and the place was selected for the bulk sample for washability test on 2-5-44. The bottom 13 ft. seam selected for washability test gave 24·10 per cent. ash ; and 4 ft. of the seam above this 13 ft. section gave 41·80 per cent. ash. Proximate analysis of the bottom 13 ft. section :—

(Selected for washability tests)

	Per cent.
Moisture	0·90
Volatiles	21·00
Ash	24·10
Fixed Carbon	54·00
	100·00

Calorific value of the coal	*6,520 calories.*
Nature of the coal	Coking.
Colour of the ash	White to ash grey.

Drifts

No. 3 Drift (Kedla)

(The sample was cut on 7-4-1944)

The Section of the seam sampled :—

Ft.	In.	CARBONACEOUS SHALE ROOF	Ash. Per cent.
2	7	Inferior Coal with several laminated bands . .	30·40
0	10	Coal	25·60
2	6	Coal	22·10
1	0	Coal	27·30
0	3	Bony coal band	38·80
1	6	Coal	21·90
0	5	Bright coal	18·60
1	2	Coal	28·10
0	4	Shale band.*	
3	10	Coal	26·50
14	5	SHALE FLOOR	

If the 4 in. shale band and the 3 in. bony coal band of 38·80 per cent. ash were excluded, the seam would give the following proximate analysis :—

	Per cent.
Moisture	0·65
Volatiles	20·90
Ash	25·83
Fixed Carbon	52·62
	100·00

Calorific value of the coal . . . . 6,410 calories.

Nature of the coal . . . . Coking.

Colour of the ash . . . . White to grey.

Drifts

No. 4 Drift (Kedla)

(Sampled on 17-4-44)

Section of the seam :—

Ft.	In.	BUFF COLOURED SHALE ROOF	Ash. Per cent.
1	8	Carbonaceous shale.*	
1	3	Coal	19·40
0	4	Shaly band, decomposed *matti* band.	
2	6	Coal	17·40
1	1	Coal	19·70
0	4	Shaly band.*	
0	10	Soft coal	12·50
0	2	Shaly band.*	
0	10	Bony coal (soft)	35·20
0	2	Band.*	
0	6	Bright coal	16·90
0	5	Dull coal (soft)	22·30
4	3	Coal, friable	20·80
14	4	SHALE FLOOR	

The total rejection of bands marked with * in the above section will be 2 ft. 8 in., *i.e.*, nearly 18 per cent.

The proximate analysis of the whole seam excluding the bands marked with * is :—

	Per cent.
Moisture	4·15
Volatiles	21·30
Ash	20·70
Fixed Carbon	53·85
	100·00

Calorific value of the coal	6,530 calories.
Nature of the coal	Non-coking
Colour of the ash	Light Buff.

Trial Pits

No. 2 Pit (Kedla)-Kadamgahra No. 2 Pit, dated 18-4-44

Section of the seam :—

Ft.	In.	*Matti* AND SHALE MIXED (DECOMPOSED ROCKS)	Ash. Per cent.
2	7	Shaly coal (mixed with clay).	
1	9	Coal	29·20
0	5	Band.*	
1	5	Coal	21·40
0	3	*Matti Band** (Decomposed shale).	
2	10	Coal	27·30
0	9	Shale.*	
2	0	Coal	26·40
0	4	Shale band.*	
0	8	Coal	41·00
13	0	SANDY FLOOR	

The top 9 ft. 5 in. of the seam leaving one foot in the floor and 2 ft. 7 in. in the roof will be a moderately good section for working this seam. The average rejection of this portion will be only 1 ft. 5 in., *i.e.*, 15 per cent. approximately, when the average ash content of this section becomes 26·44 per cent. whereas the ash content of the whole section leaving out the bands marked with * is 28·20 per cent.

Proximate analysis of the full section of 13 ft. of the seam is :—

	Per cent.
Moisture	3·70
Volatiles	19·10
Ash	28·20
Fixed Carbon	49·00
	100·00

Calorific value of the coal	5,930 calories.
Nature of the coal	Non-coking.
Colour of the ash	Light Buff.

Trial Pits

No. 3 Pit. (Nowadi)—Sample was cut on 8-4-44.

Section of the seam is :—

Ft.	In.	ROOF DECOMPOSED SOFT SHALE AND SANDSTONE	Ash. Per cent.
1	0	Coal	25·80
0	6	Shale band.*	
2	7	Coal	25·20
0	5	Band, shaly.*	
1	8	Coal	26·20
0	9	Inferior shaly coal (not tested).	
1	0	Coal	30·20
0	3½	Band, shaly.*	
1	2	Coal	25·50 (excluding 3 in. band).
0	3	Band*	
0	2½	Coal	
9	10	SANDY SHALE FLOOR	

Total rejection is 2 ft. 3½ in. or 23·11 per cent. of the full section.

The proximate analysis of the whole sample leaving out the bands marked * is :—

	Per cent.
Moisture	1·25
Volatiles	19·00
Ash	26·30
Fixed Carbon	53·45
	100·00

Calorific value of the coal . . . . 6,420 calories.

Nature of the coal . . . . Coking.

A further exposure of the bottom part of the same seam was sampled from the outcrop a little away to the rise.

Sampled on 10-5-44.

Ft.	In.	
8	5	26·30 per cent. Ash—Top part of the seam sampled.
0	5	Shaly, Carbonaceous* (not tested).
1	3	Coal (2) 41·10 per cent Ash.
2	0	Carbonaceous laminated shale.
5	4	Ferruginous sandstone and siliceous shale.
6	0	Coal 39.45 per cent. Ash.
23	5	CARBONACEOUS SHALE FLOOR.

Trial Pits

A sectional sample was drawn of the seam on 16-5-44.

The section of the seam is :—

Ft.	In.	SHALE DECOMPOSED (SANDY)	Ash Per cent.
2	9	Coal	35·50
1	8	Coal, laminated	25·70
1	8	Shale, band.*	
2	5	Coal	29·10
0	8	Shale band.*	
1	5	Bony coal	44·40
10	7	SHALE FLOOR	

The proximate analysis of the whole seam leaving out the bands marked with * is :—

	Per cent.
Moisture	2·65
Volatiles	19·00
Ash	32·90
Fixed Carbon	45·45
	100·00

Calorific value of the coal	5,570 calories.
Nature of the coal	Non-coking.
Colour of the ash	Light Buff.

No. 5 Pit (Harkatwa) – Dated 21-4-44.

Ft.	In.	LAMINATED SHALE ROOF	Ash. Per cent.
2	9	Bony coal (4)	22·40
0	6	Shaly band.*	
3	3	Hard coal (3)	28·60
1	1	Coal, shaly (2)	30·60
4	10	Coal	37·00
12	5	SHALE FLOOR	

The total rejection of shale band for the whole section will be only 6 inches, *i.e.*, 4 per cent. approximately and the proximate analysis is as follows :

	Per cent.
Moisture	1·20
Volatiles	20·30
Ash	30·50
Fixed Carbon	48·00
	100·00

Calorific value of the coal .	5,800 calories.
Nature of the coal . .	Coking.
Colour of the ash	White to grey.

Trial Pits

No. 6 Pit (Loiyo)—Sampled on 21-4-44.

Ft.	In.	ROOF-MATTI (DECOMPOSED SHALE)	Ash. Per cent.
2	8	Shaly coal (5)	23·10
1	8	Shaly coal (4)	28·70
2	10	Coal (3)	19·60
1	8	Banded coal (2)	34·10
6	10	Coal (1)	20·80
15	8	SHALE FLOOR	

The proximate analysis of the whole section of 15 ft. 8 in. without any rejection is as follows :

	Per cent.
Moisture	3·50
Volatiles	23·40
Ash	24·10
Fixed Carbon	49·00
	100·00

NOTE.—The bottom 13-ft. section selected for the washability test has low moisture and is coking coal. The 2 ft. 8 in. top shaly coal got mixed up with decomposed drifted stuff and hence the moisture content of the seam is so high and so different from the sample cut from the level's main face. The coking property of the seam is affected by the presence of high moisture in the coal.

Calorific value of the coal (whole seam 15 ft. 8 in.) .	6,150 calories.
Nature of the coal	Non-coking.
Colour of the ash	Light buff.

No. 7 Pit (Loiyo)—Sampled on 21-4-44.

MATTI AND DRIFTED STUFF ROOF	Thickness. Ft.	In.	Ash. Per cent.
Carbonaceous shale*	2	7	
Coal	0	6	2·50
Shale band* (soft)	0	2	
Coal (4)	4	3	15·60
Shaly coal (3), bony	1	1	34·60
Coal (2)	3	0	21·50
Jhama coal (1)	1	6	22·80
SHALE FLOOR	13	1	

The proximate analysis of Loiyo 13 ft. 1 in. section leaving out the top shale band (2 ft. 7 in.) and the 2 in. soft shale band marked with * is :—

	Per cent.
Moisture	3·60
Volatiles	24·50
Ash	20·90
Fixed Carbon	51·00
	100·00

Calorific value of the coal	6,390 calories.
Nature of the coal	Non-coking.
Colour of the ash	Light pink or rosy pink.

Trial Pits

No. 8 Pit (Dudhibund)—Sampled on 21-4-44.

Ft.	In.	MATTI ROOF	Ash. Per cent.
5	6	Carbonaceous shale (decomposed).	
1	9	Coal (3)	28·20
3	0	Coal (2)	22·80
0	3	Band shale.*	
4	0	Coal (1)	25·70
14	6	SHALE FLOOR	

The proximate analysis of the whole sample excluding shale band 3 in. is :—

	Per cent.
Moisture	1·40
Volatiles	23·20
Ash	25·00
Fixed Carbon	50·40
	100·00

Calorific value of the coal	6,420 calories.
Nature of the coal	Coking but it yields rather soft and lean hard coke.
Colour of the ash	Light Buff.

No. 9 Pit (Gose)—The sample was cut on 13-6-44.

The section of the seam is as follows :

Ft.	In.	SANDSTONE AND DRIFTED MATERIALS—ROOF OF THE SEAM	Ash. Per cent.
4	9	Shaly coal* (not tested)	
0	6	Shale band* (variable).	
0	9	Coal, shaly	36·50
0	10	Coal	20·30
1	0	Coal	17·80 (cleaning and friable).
1	0	Coal	15·40
4	6	Shaly coal* (not tested).	
0	7	Bony coal	39·00
0	6	Bright coal	9·10
0	3	Bony coal	27·10
1	9	Coal	22·20
2	0	Coal	15·50
2	0	Bony coal	27·20
5	0	Coal	24·84
2	0	Bony coal	34·00
6	0	Coal	24·10
2	0	Coal	25·70
35	5	SHALE FLOOR	

The results of proximate analysis of the coal in whole seam (35 ft. 5 in.) leaving out the bands marked with * are as follows :

	Per cent.
Moisture	1·82
Volatiles	20·60
Ash	23·45
Fixed Carbon	54·13
	100·00

Calorific value of the coal	6,500 calories.
Nature of the coal	
Colour of the ash	Light grey.

Trial Pits

No. 10 Pit (Lartongritoli)-Kedla Area

Ft.	In.	BLACK SHALE ROOF	Ash. Per cent.
1	9	Coal	34·10
1	8	Black shale band.*	
3	2	Coal	35·20
0	6	Shale band.*	
1	10	Coal	31·50
1	2	Black Shale Parting.	

No. 10A Pit

Ft.	In.	SHALE AND SANDSTONE ROOF	Ash. Per cent.
1	0	Coal	33·50
0	3	Shale band.*	
2	6	Coal	36·80
3	9	SHALE FLOOR	

(1) Total rejection of the whole (8 ft. 11 in.) seam in the top section only as exposed in No. 10 Pit will be 2 ft. 2 in., *i.e.*, 24·3 per cent.; and the proximate analysis of this section leaving out the bands marked with * is :—

	Per cent.
Moisture	1·55
Volatiles	19·20
Ash	33·00
Fixed Carbon	46·25
	100·00

Calorific value of the coal	5,670 calories.
Nature of the coal	Non-coking.
Colour of the ash	Fair tly Pink.

The bottom section (3 ft. 9 in.) as exposed in No. 10A Pit, gives the following proximate analysis leaving out the 3 in. shale band :—

	Per cent.
Moisture	2·25
Volatiles	15·80
Ash	36·80
Fixed Carbon	45·15
	100·00

Calorific value of the coal	5,360 calories.
Nature of the coal	Non-coking.
Colour of the ash	Light pink.

No. 12 Pit (Lerwatoli)—Sampled on 17-4-1944

Ft.	In.	CARBONACEOUS SHALE (LAMINATED CLEATY BARAKAR SHALE) ROOF.	Ash. Per cent.
4	4	Weathered Shaly coal	24·10
1	10	Coal	30·30
0	4	Shaly coal.*	
3	2	Coal	27·80
2	7	Coal	31·00
0	3	Band Shaly	
0	9	Coal	45·20
0	5	Band Shaly . .	
0	6	Coal Shaly	42·30
5	0	Sandstone parting.*	
1	9	Coal	24·50
0	4	Band, Shaly.*	
3	5	Coal	35·30
0	5	Shaly coal.*	
25	1	SHALE FLOOR.	

The drifts and trial pits have been made in the different coal seams as follows :

Drift Nos. 1, 2, 3 and 4 and Trial pit in the Kedla seam
Nos. 5, 6 and 7.

Trial pit Nos. 2 ,3 ,4 and 8 . .	In the seam immediately underlying the Kedla seam ;
Trial pit No. 12	In the seam just below the above ;
Trial pit No. 9	In the thick seam W. N. W. of Gose;
Trial pit No. 10	In the seam cropping out in the Pindra *nala*.

It has already been mentioned that the succession of the coal seam in West Bokaro beginning from the lowermost No. 1 was established in Blocks A and B based on the report of rocks met with in Chowdhury's deep hole No. 1 and Barughutu borehole No. 1. Further, the Kedla-Loiyo area lies on the downthrow side of a fault which separates it from Blocks A and B. This area contains an outcrop of the Kedla seam which appears to be the best of all the seams found therein both in extent and quality. This seam, according to Bokaro and Ramgur Ltd., is the No. 21 seam and it would thus be natural to expect the other well-known lower seams, such as Nos. 10 and 9 seams, to occur in depth. With a view to proving these lower seams, Mr. Roberton put down a borehole (known as Roberton's Kedla borehole No. 1) in which the Archaeans were struck at a depth of 800 ft. without proving the important lower seams.

From the sections and analyses of samples from the several drifts and trial pits it would appear that the Kedla seam varies in thickness from 12 ft. 5 in. to 23 ft. 9 in. and in ash content from 20·70 per cent. to 30·50 per cent. and also that the coal is of coking variety. The existence of the seam has been proved in the Kedla Block in Chowdhury's boreholes Nos. 1, 2, 3 and 4 and in Lathbury's hole.

In the Loiyo Block this seam has been proved in Chowdhury's borehole No. 5. The areas of the Kedla and the Loiyo Blocks will be nearly 5,000 and 1,800 bighas respectively and the reserves of the Kedla seam coal in the two blocks will be nearly 40 and 10 million tons respectively.

In terms of quarriable coal the reserves of the Kedla seam are given below :

Western portion—

776,400 tons	with	overburden	equal to the	thickness	of the	Seam.
1,552,800 tons	,,	,,	twice	,,	,,	,,
2,329,300 tons	,,	,,	thrice	,,	,,	,,

Eastern Portion—

218,800 tons	with	overburden	equal to the	thickness	of the	seam.
437,600 tons	,,	,,	twice	,,	,,	,,
656,400 tons	,,	,,	thrice	,,	,,	,,

Washability tests have been carried out with coals of the Kedla seam from drift No. 2 and trial pit No. 6 without much encouraging results.

Other seams in the Kedla-Loiyo area are of indifferent quality excepting the Gose seam which is noteworthy in one respect that the No. 9 pit proved its thickness as 35 ft. 5 in. containing 23·45 per cent. ash, thus suggesting the possibility of its correlation with the Kargali Seam (13 Seam of East Bokaro).

CHAPTER VII

DESCRIPTION OF THE GEOLOGY AND COAL SEAMS IN THE RANIGANJ MEASURES

Coal seams in the Raniganj series had been recorded by Hughes from different localities in East and West Bokaro areas but they are few in number, thin and generally not attractive. During the present survey also several coal seams have been located in the Raniganj series These are generally thin varying in thickness from one to six feet, although a coal seam has been noted in West Bokaro, having a thickness of 10 feet, the maximum so far noted. The coal in each case appears to be of inferior quality having no economic importance. The coal seams are interbedded with shales, at times carbonaceous, and sandstones which are medium to fine grained in texture, often thin bedded and are generally of a light greyish colour.

EAST BOKARO

North of Pindra (23°47¼′ : 87°45′) on the right bank of the Bokaro river there is an outcrop of coal terminated by N.N.E.—S.S.W. fault to its east. This coal seam is six ft. thick and is dipping S. 10° E. at 15°. The coal is seen interbedded with shale bands and appears to be of no economic importance. A little west of this coal outcrop there is a band of shaly coal exposed also on the right bank of the Bokaro river underlying the coal seam.

About a mile east from here there are three outcrops of coal seams. the thickest being about five ft. These coal seams are exposed in *nalas* joining the Bokaro river on its right bank and are very much weathered out. They do not appear to be attractive so far as quality is concerned.

East of Pindra there is a coal seam five feet thick exposed across the Pindra *nala*. It is dipping west-south-west at 10°. Also, about a couple of furlongs further up the *nala* another coal seam is exposed ; this has almost the same direction and amount of dip as the above mentioned coal seam and has a thickness of only two feet and six inches. Both the coal seams appear to be of inferior quality.

Outcrops of five coal seams are noted in the *nala* west of Kharwatanr (23°45′ : 85°48′). The lowermost and the uppermost seams are thin while the second, third and fourth from the bottom are 2½ ft., 2 ft. and 5 ft. respectively in thickness. The coal seams are dipping north-west at fairly high angles of about 30°. They do not appear to contain good coal worth working. Upstream of the same *nala* and intervened by a fault there is an outcrop of another coal seam nearly 5 feet thick. This is dipping almost westwards also at about 30°.

WEST BOKARO

In the West Bokaro area a none too extensive wedge-shaped outcrop of the Raniganj beds extends eastwards from Taping (23°50′ : 85°30′) through Pindra (23°49½′ : 85°30¾′), Barisam (23°49′ : 85°32½′) and Basantpur (23°49′ : 85°34′) and is ultimately terminated against the Barakars by an almost north-south fault two furlongs east of Kotre (23°49′ : 85°34¾′). The rock consists predominantly of greyish white fine-grained sandstone with decomposed felspars, weathering to a yellowish-green sandy rock. Interbedded shales, at times carbonaceous, and coal seams are found. False-bedding is very commonly noticed.

An outcrop of coal seam is seen south-east of Kotre. This has a thickness of 10 feet and is dipping south-west at 12°. From the look of the coal seam at the outcrop, the coal appears to be of inferior quality with not much of economic importance.

A small exposure of a thin seam of coal is found in the Taping *nala* (meeting with the Chutua *nala* E.N.E. of Barisam) about ¾ mile north-west of Ulhara (23°49′ : 85°32′). The quality of the coal appears to be much too inferior to be of any economic value.

A thin coal seam dipping east-north-east at 20° is found in the above mentioned *nala* north-east of Pindra. Another outcrop of a coal seam is seen in the same *nala* about five furlongs east of Taping. This seam is not more than four feet in thickness and dips west-south-west at 15°. Both these coal seams appear to contain inferior coal of no economic importance.

PART III

CHAPTER VIII

DESCRIPTIONS OF FIRECLAY AND OTHER DEPOSITS

Fire-clay

Several beds of fire-clay have been noted in the East Bokaro area. Out of these the fire-clay bed underlying the Top Karo Seam and occurring in the small hills east and west of the Dhori-Dumri motor road appears to be the most promising (Pl. V, fig. 2). It has an average thickness of six feet and is usually of a dark greyish colour. The fire-clay was being quarried (in 1944-45) by several small contractors and despatched to Kumardubi and Raniganj for making fire-bricks, etc. A sample of the fire-clay was tested with the following results :—

Plasticity	Poor.
Shrinkage (linear)	5 per cent.
Colour—	
Unburnt	Mouse grey.
Burnt	White.

The sample does not fuse at a temperature of 1500°C. The fire-clay, therefore, is exceptionally suited for the manufacture of fire-bricks. With the addition of kaolin and the consequent lowering of melting point the fire-clay could be moulded into any shape.

The fire-clay deposits of the East and West Bokaro coalfields were investigated separately by the Geological Survey of India in 1948 as a part of the ceramic raw materials investigations.* In East Bokaro the fire-clays occur as bands associated with coal seams lying both above and within them. They are usually black or greyish in colour, occasionally brownish and have specific gravity varying between 2·6 and 27. The fire-clays are of the non-plastic type and would need blending with a bonding clay for use in the manufacture of refractory articles. The reserves calculated down to a workable depth of 50 ft. in each are as folllows :

Fire-clay associated with—		
Kargali Seam	2,504,956 tons	(approx.)
Bermo Seam	331,000 tons	,,
Karo Seam	2,523,000 tons	,,
Total	5,358,956 tons	,,
or say	5,359,000 tons	,,

*Investigations carried out by Messrs. D. R. S. Mehta and G.G. K. Sastrii

In the West Bokaro area fire-clays occur either overlying or underlying coal seams in the Leiye and Mandu areas and include refractory shales. Occurrences of isolated pockets of fire-clay are not uncommon. The fire-clays are generally fairly regular in nature maintaining almost constant thickness and quality, although in some cases there are quick variations. In the samples collected and tested it has been found that the plasticity is always poor and the linear shrinkage varies from 7·50 per cent. to a maximum of 25·00 per cent. but in every case the clays have been found not to fuse at 1350°C. The reserves of available material calculated down to a workable depth of 50 ft. (and excluding about 12 per cent. of the material already worked out and thrown away) may be taken to be 450,000 tons approximately.

Other clays

These deposits include the light coloured clays which are locally used for whitewashing purposes. In the Hetua *nala*, north-east of the deserted cluster of huts at the west-north-western end of Ulhara village (23°48′ : 85°32′), at the junction of the small curved *nala* with the Hetua *nala* there are several faults, so that the Raniganj rocks consisting of sandstones and shales are very much faulted and crumpled. Some *jhama* is also noticed there. The rocks are bleached and at places kaolinised ; the white earth is extracted and taken away by villagers for whitewashing their houses. Cattle and wild animals also eat the white earth.

Railway Ballast

In the Damarbara-Ara area in West Bokaro the whole of the Barakar country is covered with loose pebbles, derived from the conglomeratic sandstones. These pebbles, broken into suitable size, are being used at present as railway ballast. The possibility, however, exists of utilising these pebbles, at least those of purer varieties, in glass making.

Calc-tufa

An occurrence of calc-tufa is noted in the Upper Panchet rocks a little over half a mile north-east of Murpa (23°45′ : 85°41¾′) towards the base of the southern scarps of the Lugu hills. It is of cream colour and slightly porous. Patches containing a large number of recent mollusc shells are found in this deposit. It is spread over an area of about 72 acres.

The calcareous matter appears to have been carried down by descending waters percolating from the overlying Upper Panchet sandstones which evidently contain some calcareous matter and is deposited close to the junction of the Upper and Lower Panchet rocks. Up the Lugu hill on the plateau running water in a long winding *nala* is apparently lost as it enters caverns in the sandstones gently tilted southwards along the dip slope of the beds towards the southern edge of the plateau. Some hundreds of feet below the water emerges out near the base of the hill and deposits the tufaceous material near the point of emergence over a narrow zone on either side of the shallow, hanging *nala*. The total quantity of material available is not large probably not exceeding 1,000 tons. It appears to be of fairly good

quality as will be seen from the analysis of an average sample which gives the following results :—

	Per cent.
SiO_2	0·46
R_2O_3	0·36
CaO	54·25
MgO	1·12
Loss on ignition	43·66
Total	99·85

The calc-tufa is quarried on a small scale and burnt for lime near Chainpur railway station.

Kankar

Accumulations of *kankar* disseminated over the surface of the sandstones are noticed at several places. These have apparently been formed by the gradual evaporation of the carbonate material brought up in solution and consist of impure calcareous material mixed with sand. The *kankar* is collected and burnt for lime for local use.

Iron-ore

A local segregation of magnetic iron-ore (magnetite) is noted southwest of Barughutu, about 40 yards E.N.E. of Barughutu borehole No. 5. This seems to have originated from the segregation of the iron contents concentrating in one place to form the magnetic iron-ore. This occurrence is a local one and does not appear to have any economic importance. Patches of marcasite are sometimes noted enclosed in the coal seams. One such patch is found in the 11th seam outcrop in the stream joining with the Chutua *nadi* E.N.E. of Drift No. 2, about a mile north-east of Banji.

Segregations in the form of nodules of impure limonitic iron-ore have been smelted by the local *lohars* or iron-smiths at several places in the coalfield in the primitive country furnaces using charcoal made from the local timber. Heaps of slags as also broken pieces of the furnace are seen at many places but nowhere the industry is in existence at the present day.

The iron-ore has been segregated from the decomposition of the Barakar rocks, particularly the sandstones of the middle portion and have formed into irregular nodules which are rather siliceous and are inferior in quality.

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GEOGRAPHICAL INDEX

Locality	Latitute Deg.	Latitute Min.	Longitude Deg.	Longitude Min.
Amlo (Emlo)	23	46½	85	59½
Ara (Aradih)	23	46	85	33½
Asnapanitoli	23	46	85	54
Baghaltatoli	23	45	85	33
Baladhohar	23	48	85	26½
Bandh	23	46	85	52
Banji	23	48	85	35½
Banwar	23	44½	85	29½
Barisam	23	49	85	32½
Barkaberatoli	23	47½	86	02
Barkakana	23	37	85	29
Barughutu	23	48	85	35½
Basantpur	23	49	85	34
Bermo	23	46¼	85	57¾
Bhadwa	23	44	85	35
Bhurkunda	23	44½	85	25½
Bhutahitoli	23	47½	85	32
Birsa	23	47¼	85	47
Bokaro	23	47	85	57¾
Borea	23	46½	85	53
Budkaro	23	47	85	58
Calantha	22	32	88	20
Chainpur	23	44	85	35
Chandrapura	23	45¼	86	07¼
Charhi	22	38	85	43
Daka Saram	23	47	85	29¼
Daltonganj	24	03	84	05
Danea	23	47½	85	39½
Datma	23	44	85	28½

GEOGRAPHICAL INDEX—*contd.*

Locality	Latitude Deg.	Latitude Min.	Longitude Deg.	Longitude Min.
Dhendhe	23	47	85	47½
Dhewthatanr	23	47	85	39
Dhori	23	45¾	85	59½
Dumarbera	23	45	85	32
Dumri	23	59½	86	01
Duni	23	46¼	85	33
Duru Kasmar	23	48½	85	33
Garkia (Parsabera)	23	46	85	35
Ghato	23	47¼	85	35½
Gobindpur	23	48	85	53
Gomoh	23	52	86	10
Gosi	23	48½	85	46
Gumia	23	48	85	50
Hazari	23	47	85	51½
Hesagara	23	45½	85	33½
Ichakdih	23	48	85	36½
Jarangdih	23	46	85	56
Jaridih	23	46	85	56½
Jhirki	23	46	85	51
Kargali	23	46½	85	58¾
Kathhara	23	46	85	53¼
Kedla	23	48	85	35½
Keke Basaudih	23	48	85	30
Kharwatanr	23	45	85	48
Khudgara	23	47½	85	50½
Kodwatanr	23	45	85	47½
Koiyotanr	23	48	85	45
Kotre	23	49	85	34¾
Kuju	23	43¼	85	30¼
Kundri	23	43	85	32½

GEOGRAPHICAL INDEX—*contd.*

Locality	Latitude		Longitude	
	Deg.	Min.	Deg.	Min.
Kusumtoli	23	47¼	85	45½
Lahariatanr	23	47	85	52
Lartengritoli	23	46½	85	35
Loiyo	23	47½	85	38½
Makoli	23	46½	86	02
Makundaberatoli	23	46½	85	34
Mandu	23	48	85	28
Mianbandh	23	47	85	48½
Murpa	23	44	85	31
Nauniaberatoli	23	49½	85	29½
Nowadih	23	44	85	31
Ocho	23	48	85	48
Palihari-Gurudih	(See Pipradih)			
Parej	23	48	85	32½
Parsabera	(See Garkia)			
Parsatoli	23	45	84	32¼
Phusro	23	46	86	01
Pichhri	23	45	86	01½
Pindra	23	47¼	85	45
Pindra	23	49½	85	30¾
Pindratanr	23	46	85	48
Pipradih	23	48¼	85	50
Pundi	23	46½	85	31½
Rajabera	23	45	86	04
Ranchi Road	23	40	85	31
Saram	23	46	85	49
Sarubera	23	46	85	33
Sawang	23	48½	85	51
Simra *tungri*	23	47½	85	37½
Sunughututoli	23	47¾	85	32

GEOGRAPHICAL INDEX—*concld.*

Locality	Latitude		Longitude	
	Deg.	Min.	Deg.	Min.
Taping	23	50	85	30
Toera	23	45½	85	28
Topa	23	44	85	28½
Tulbul	23	47	85	46
Turio	23	45	86	02½
Tutijharna	23	48	85	42
Uchitdih	23	45½	85	52½
Ulhara	23	49	85	32

APPENDIX

INTERIM REPORT OF THE RESULTS OF THE EXPLORATION OF THE BOKARO COALFIELD

BY

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(With one sketch-map.)

1917.

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I. INTRODUCTION

I have now been engaged on this work for portions of two field-seasons, *viz.*, from January 1st to June 5th, 1916, and from November 1st, 1916, to March 30th, 1917. After the close of the 1st period of work, I submitted a brief report, dated 14th August, 1916, and entitled "Report on the work necessary for the completion of the economic investigation of the Bokaro Coalfield during the field-season 1916-17". During the second period, I carried out a combined programme of sampling coal-seams (west of Lugu Hill), diamond drilling (east of Lugu), and geological mapping, on the lines adumbrated in the foregoing report. My plan of work for the second period was drawn up on the assumption that a full field-season would be available, but I was compelled to close my own field work some 6 weeks earlier than contemplated, with the result that I was unable to finish the geological survey of the villages of Jaridih Kathhara, Bandh, Palani, Jhirki, Sarum and Hesir, and some work projected near Bermo required to complete the correlation between the succession of rocks and seams as established by me in the country west of the Gobindpur fault and the succession as worked out by Mr. Ward for the ground east of this fault. Without having completed the detailed survey of the villages mentioned, it is of course impossible to speak authoritatively as to their economic value, but my general impression, based on the faulting and dip of the rocks, is that the portions of the Kargali seam underlying these villages will prove to be either too faulted (*e.g.*, in Kathhara), too highly-inclined, or too deep below the surface (*e.g.*, Sarum and Palani), to be worth consideration from the economic point of view.

The premature closure of my field work did not, however, interfere with the sampling or diamond-drilling. All sampling then proposed had already been completed, and I was able to arrange for the continuance of diamond drilling until my programme was completed, the last hole being finished this October. In order to keep an eye on this work and examine the accumulated cores, I was permitted to revisit the field in August for a few days.

On leaving the field at the end of March, I was attached to the Indian Munitions Board in Simla for two successive periods of three months, where the work undertaken gave me very little leisure for the consideration of Bokaro problems, and on reverting to the Geological Survey, I was at once allotted a programme of field work on minerals urgently required for the conduct of the war.

I have mentioned the foregoing points in order to explain why it is at present impossible for me to draw up a full report on the Bokaro exploration. I hope to obtain the necessary leisure next hot weather, but meanwhile must content myself with giving a brief account of the salient economic results, sufficient, I hope, to enable the Railways and Bokaro and Ramgarh, Limited, to take early such action as may prove desirable in furthering the development of the Bokaro coalfield.

In order to avoid repetition, it is assumed that this report will be read in continuation of the earlier report.

The work carried out last winter may be divided into two portions :—

(1) Examination of section 3 of the West Bokaro field (west of Lugu Hill)

(2) The continuation of work on the Gumiya section of the East Bokaro field (east of Lugu Hill).*

II. THE WEST BOKARO COALFIELD

As already related, Mr. Church divided the West Bokaro field into 7 sections. According to his original report, none of these sections contains any workable thickness of first-class coal ; but, according to his revised report, seams 4, 7 and 8 in section 3 (Kedla-Jharna) do contain workable first-class coal. According to Mr. Lathbury who subsequently tested the seams indicated by Mr. Church, these seams do not contain any fuel of value "either for railway purposes or from a commercial point of view".

---

*The Bokaro coalfied is divided by the huge mass of Panchet rocks constituting Lugu Hill into what are for all practical purposes two separate coalfields, which may be conveniently designated the West Bokaro Coalfield and the East Bokaro Coal field according to their position with reference to Lugu Hill.

In planning my visit to West Bokaro I decided to confine my attention, in the first instance, to resampling the seams in Mr. Church's section No. 3. If the result of my work were to confirm Mr. Church's revised opinion that these seams contain workable first-class coal, then it would be necessary to recommend an extensive programme of detailed geological mapping, diamond-drilling and sampling of the West Bokaro Coalfield, probably necessitating three full field-seasons work by whoever undertook it. If the result of my work were to confirm Mr. Lathbury's results, then, assuming Mr. Church were correct in selecting section 3 of the field as the best, I should be unable to recommend any further expenditure on the exploration of West B okaro.

The period devoted to West Bokaro was only some six weeks, but this was ample to enable me to resample the seams in question and to examine a portion of the surrounding geology. Mr. Church obtained his samples by driving inclines, and Mr. Lathbury by cleaning out and lengthening Mr. Church's inclines. As these inclines were largely full of mud, I made no use of them for sampling purposes, but instead sank prospecting shafts, taking my samples from vertical cuts through the portions of the seams to be sampled.

It is uncessary in this preliminary report to give in full the whole of the large number of analyses of samples from both West Bokaro and the Gumiya section of East Bokaro, and, as a rule, only the ash contents will be quoted. The results of the tests by Messrs. Church, Lathbury and myself on the seams in the Kedla-Jharna section may then be tabulated as follows :

Seam 4.

Church, original report.				Church, revised report.				Lathbury.				Fermor.			
Ft.	In.	Ash Per cent.		Ft.	In.	Ash Per cent.		Ft.	In.	Ash Per cent.		Ft.	In.	Ash Per cent.	
18	0	33·21		..		..		16	0	32·49		17½	0	Not sampled.	
1	0	15·46		..		..		2	0	23·50		1	0	24·13	
1	0	21·85		..		..		0	9	14·40		1	0	19·41	
1	0	27·02		..		..		0	6	26·60		1	0	20·62	
1	0	15·67		..		..		0	7	18·75		..		..	
1	0	13·30	9 ft. average 9·75 per cent ash. (33·21 to 16·51)	..		..	8 ft. average 15·03 per cent. ash.	1	0	17·95	8 ft. average 19·89 per cent. ash. (32·49 to 16·20)	..		..	8 ft. average 20·36 per cent. ash. (24·13 to 12·37)
1	0	20·38		..		..		0	6	13·90		1	0	12·32	
1	0	28·71		..		..		1	0	20·25		1	0	21·37	
1	0	18·87		..		..		1	0	29·00		1	0	27·83	
1	0	16·51		..		..		1	0	21·35		1	0	25·56	
1	0	28·32		..		..		0	6	20·35		1	0	23·44	
1	0	31·63		..		..		1	2	16·20		1	0	12·37	
1	0	23·83		..		..		2	0	36·15		1	0	32·92	
1	0	13·40		..		..		..		..		1	0	31·93	
1	0	21·16		..		..		2	0	16·60		1	0	18·96	
1	0	21·18		..		..		—		—		1	0	15·94	
1	0	30·03		..		.		2	0	20·95		1	0	23·90	
1	0	45·95		..		..		2	0	32·40		2½	0	Not sampled.	
1	0	19·37		..		..		2	0	32·40		—			
36	0							36	0			34	0		

Seam 7.

Church, original report.		Church, revised report.		Lathbury.			Fermor.		
Ft. In.	Ash percent.	Ft. In.	Ash Per cent.	Ft. In.	Ash Per cent.		Ft. In.	Ash Per cent.	
6 0	28·16	4 10	11·05	1 3	41·90	4 ft. 8 ins. average 24·69 per cent. ash. (1 ft. 3 in. to 0 ft. 9 in.)	1 7½	44·36	4 ft. 6 ins. average 26·48 per cent. ash. (1 ft. 7½ in. to 0 ft. 11 in.)
				0 9	28·42		1 0	19·09	
				0 5	15·75				
				0 6	15·00		1 0	15·94	
				1 0	17·15		0 11	14·32	
				0 9	13·70				
8 9	Stone	..	..	12 6	Shale		15 0	Shale	
1 0	43·01	..	..	..	..		..	..	
1 0	21·16	..	..	2 0	24·90				
1 0	23·45	..	..	..	..				
1 0	36·03	..	..	2 0	31·40				
1 0	24·02	..	..	..	..		11 4	Not sampled.	
1 0	27·99	..	..	2 0	31·40				
1 0	33·09	..	..	2 0	21·40				
1 0	25·40	..	..	2 0	28·55				

1 0	14·09		..	..		0 6	16·00		1 2	28·96	
..	..		..	..		0 5	36·20		..	..	
1 0	19·07		..	..		0 6	19·40		1 0	23·30	
..	..		..	..		0 6	23·57		..	..	
1 0	33·13		..	..		0 4	19·45		1 0	24·88	
..	..	7 ft. average 21·46 per cent. ash.	..	..	6 ft. 6 ins. average 17·32 per cent. ash.	0 6	26·20	6 ft. 4 ins. average 23·67 per cent. ash.	..	..	6 ft. 8 in. average 25·70 per cent. ash.
1 0	27·91		..	..		0 7	23·75		1 0	18·21	
..	..		..	..		..	..		..	..	
1 0	20·51		..	..		0 5	26·25		..	..	
..	..		..	..		..	..		..	..	
1 0	18·79		..	..		0 10	14·10		1 0	25·35	
..	..		..	..		..	..		..	..	
1 0	16·69		..	..		1 9	28·10		1 6	29·87	
1 0	47·43		..	..		..	..		..	..	
1 0	32·15		..	..		..	..		..	..	
31 9						33 6			37 6½		

Seam 8.

Church, original report.		Church, revised report.		Lathbury.		Fermor.	
Ft. In.	Ash Per cent.	Ft. In.	Ash Per cent.	Ft. In.	Ash Per cent.	Ft. In.	Ash Per cent.
5 8	22·45	6 0	10·50	1 3	28·95 } 6 ft. average 19·96 per cent. ash.	2 0	33·52 } 5 ft. 9 ins. average 21·86 per cent. ash.
2 9	26·69	..	..	0 6	38·80	1 9	16·51
				..	..	..	..

The foregoing figures speak for themselves. Summarising my own results, I find that the portions of the seams in question show the following average ash contents :—

No. of seam.	Thickness sampled. Ft.	In.	Ash Per cent.
4	8	0	20·36
7 (base)	6	8	25·70
7 (top)	4	$6\frac{1}{2}$	26·48
8	5	9	21·86

If we accept Mr. Church's conclusion that section 3 of the field is the best, I cannot, in view of the above figures, recommend any further expenditure on the exploration of West Bokaro.

In this connection, however, it is necessary to point out that the time at Mr. Church's disposal was comparatively short, and could not be regarded as sufficient for an exhaustive examination of the West Bokaro field. Moreover, such observations as I have made lead me to differ from Mr. Church both as to the composition of the seams investigated and as the structure of section No. 3. In fact, I find myself entirely in agreement with certain conclusions arrived at by Mr. Lathbury, *viz.*, that Mr. Church's seams Nos. 3 and 4 are one and the same seam repeated by faulting, that seams Nos. 5 and 6 of Mr. Church are non-existent (except for 1 ft. of coal) and that the inferior bands in the coal do not on the average become thinner to the dip, as I verified by completely cleaning out one of the old inclines.

We cannot, therefore, exclude the possibility that a revised survey of West Bokaro might make it necessary to modify Mr. Church's conclusions as to the relative merits of the sections into which he has subdivided that part of the field, nor must we exclude the possibility that other seams in section No. 3 than those tested may prove as good as, or possibly better than seams 4, 7 and 8, which were selected by Mr. Church for sampling because of the large area they underlay, for it must be remembered that Mr. Lathbury's and my work has been directed to the seams indicated by Mr. Church and that the quality of the remaining seams has, as a rule, been judged only from diamond-drill cores, which are very unreliable for this purpose.

From a perusal of Mr. Church's report, I am, however, inclined to agree that he has correctly selected section No. 3 as the best, but, in view of the points to which I have just drawn attention, we cannot regard the economic future of West Bokaro as necessarily so poor as the foregoing analytical figures suggest. In fact, I regard the investigation of this portion of the field as still incomplete.

I am of opinion that a thorough study of the economic possibilities of West Bokaro including a detailed geological survey with all necessary sampling and diamond-drilling, would probably take not less than 3 years, on account of the very extensive faulting, which will render very difficult the correlation of the seams. Until the exploration of West Bokaro can be undertaken in this thorough manner with the services of a geologist able to devote three consecutive filed seasons to the work, I recommend, therefore, that no further expenditure be incurred in West Bokaro.

In concluding this section, I must say that I have no facts at my disposal suggesting that the results of such an exploration would be favourable. All the available evidence points the other way, but it is not conclusive and there is still room for hope.

III. THE GUMIYA SECTION, EAST BOKARO COALFIELD

A. Geology and Correlation of Seams.

1. Geology.

The Gumiya section is the portion of the East Bokaro field bounded by the Gobindpur fault on the east and Lugu Hill on the west.

I have mapped a considerable portion of this section of the field in detail on the village maps on a scale of 16 in.=1 mile, it being impossible to insert the necessary detail on the existing 1 inch maps. But until next recess I shall not be able to reduce the information collected to a scale suitable for presentation, and must, therefore, now content myself with attaching an amplified edition of the tracing submitted with the earlier report.

The faults detected as the result of this work are exceedingly numerous, but, in spite of this, and as a result of the detailed mapping, I have succeeded in working out in detail the complete sequence of coal seams in this section of the field. These seams may be numbered from the base of the series upwards, the lowest seam (No. 1) being easily recognisable. It is usually from 6 in. to 1 ft. thick, and is overlain by a thick band of pebbly grit. At the base of this grit are scattered pebbles resting directly on the coal. Except for this basal thin seam numbers have not, as a rule, been allotted to seams that do not attain a thickness of at least 2 feet. Unimportant seams between numbered seams may be designated by letters, such as 15A, 15B and 15 C., for seams between 15 and 16.

These coal seams lie entirely in the Barakar series, which usually rests directly on the Archaean complex, but a small thickness of Talchirs is sometimes present.

The sequence of the Barakar series, worked out partly from drilling records and partly from geological observations, is shown below. with the approximate thicknesses of the rocks separating the seams. The capitals in brackets after the numbers of some of the seams are the letters used by Mr. David in his report :

—		Range of thickness.					Average thickness.
		Coal.				Rock.	
		From		To		Feet.	Feet.
		Ft.	In.	Ft.	In.		
I. Sandstones and shales with ironstone nodules in places (1,250 ft.).	Rock . .	..	..	..	..	1,250	1,250
II. Upper Non-coal-bearing sandstones and shales (1,500 ft.)	Rock . .	..	..	..	..	1,500	1,500
	Seam 29 . .	..	..	1	0	..	1
	Rock . .	..	..	..	..	10	10
	Seam 28 . .	..	..	1	0	..	1
	Rock . .	..	..	..	..	85	85
	Seam 27 . .	..	..	3	0	.	3
	Rock . .	..	..	..	..	113	113
	Seam 26 . .	8	0	10	0	..	9
	Rock . .	..	..	..	..	45—73	56
	Seam 25 (L) .	15	0	19	0	..	16
	Rock . .	..	..	..	..	12—33	23
	Seam 24 . .	1	0	3	0	..	2
	Rock . .	..	..	..	..	24—38	31
	Seam 23(K) .	9	0	18	0	..	13
	Rock . .	..	..	..	..	27—50	41
	Seam 22(J) .	5	0	6	0	..	5
III. Upper sandstones and shales with thin coal seams :—	Rock . .	..	..	..	..	18—31	26
Rock—1,087 ft.	Seam 21(I) . .	5	9	6	2	..	6
Coal— 95 ft.	Rock . .	..	..	..	..	15—84	55
1,182 ft.	Seam 20 . .	2	0	4	0	..	3
	Rock . .	..	..	..	..	95	95
	Seam 19 . .	1	0	4	8	..	3
	Rock . .	..	..	..	..	41—63	52
	Seam 18 (H) .	2	6	5	0	..	4
	Rock . .	..	..	..	..	96—157	126
	Seam 17(G) . .	4	0	7	0	..	6
	Rock . .	..	..	..	..	58—156	111
	Seam 16 . .	2	6	8	3	..	5
	Rock . .	..	..	..	..	100—229	169

		Range of thickness.					Average thickness.
		Coal.				Rock.	
		From		To		Feet.	Feet.
		Ft.	In.	Ft.	In.		
III. Upper sandstones and shales with thin coal seams—*contd.*							
	Seam 15(F) . .	2	6	16	0	..	12
	Rock . .	..	..	..	..	49—121	94
	Seam 14(E) . .	4	0	10	3	..	6
	Rock . .	..	..	..	..	111—232	140
	Seam 13(D) . .	41	0	123	0	Kargali	58
	Rock . .	..	..	..	..	125	125
	Seam 12 . .	23	0	32	0	..	27
	Rock . .	..	..	..	..	124	124
	Seam 11(D) . .	42	0	49½	0	Bermo	46
IV. Middle sandstones and shales with thick coal seams :—	Rock .	..	..	..	..	302	302
Rock—863 ft.	Seam 10(C) .	0	0	6	0	..	3
Coal—232 ft.	Rock . .	..	..	..	..	23	23
1,095 ft	Seam 9(B) . .	28	0	30	0	..	29
	Rock . .	..	.	..	..	149	149
	Seam 8(A) . .	59	0	76	0	Karo	69A
	Rock . .	..	..	.	..	140	140
	Seam 7 . .	0	6	4½	0	..	2—6
	Rock . .	..	..	..	..	23—33	28
	Seam 6 . .	5	0	7	0	..	6
	Rock . .	..	..	..	..	45—180	112
	Seam 5 . .	0	2	2	0	..	1—1
	Rock . .	..	..	..	..	10—30	20
V. Lower grits, sandstones, and shales, with thin coal seams:—	Seam 4 . .	2½	0	7	0	..	5
	Rock . .	..	..	..	..	33—84	57
Rock—511 ft.	Seam 3 . .	4½	0	5½	0	..	4—9
Coal—25 ft.	Rock . .	..	..	..	..	75—114	94
536 ft.	Seam 2 . .	4	0	5	0	..	4—6
	Rock . .	..	..	..	..	60	60
	Seam 1 .	0	6	0	12	..	0—9
IV. Basal grits and conglomerates (128 ft.).	Rock . .	..	.	..	..	128	128
	Total .	352				5,339	5,691

The rocks separating the coal seams are grits and sandstones, sometimes calcareous, and shales which are of three main types :

(1) Very micaceous sandy shales or shaly sandstones.

(2) "Blue" shales, made up chiefly of mica, quartz, and carbonaceous matter, very frequently with *Vertebraria indica.*

(3) "Black" carbonaceous shales, usually impalpably fine, except sometimes for occasional specks of white decomposed felspar. These shales are frequently rich in fossil plants, particularly *Glossopteris.*

Many of the sandstones are ferruginous at the surface, where also calcareous and ferruginous nodules sometimes occur in the shales ; but, judging from surface evidence and the diamond drill cores, these are purely surface phenomena, and there is reason for supposing that the ironstone nodules of the so-called Ironstone Shales are of similar origin.

The uppermost division of the Barakars shown in the above section contains two rather broad belts of shales with ironstone nodules, and was mapped by Hughes as Ironstone Shales. The shales and sandstones are, however, typical Barakar rocks, and similar ironstone nodules are found at intervals throughout division II and the upper division III of the coal-bearing Barakars. The rocks of the above section are separated from the overlying Raniganj series by about 100 feet of 'Ironstone Shales', the junction being exposed in Gumiya close to the Bokaro River. The highest rock exposed in the centre of the syncline in Bhurkundwatand is about 1,220 feet and in Borea about 1,100 feet up in division II, so that the Kargali seam lies about 2,400 feet and 2,300 feet respectively below the surface of these two plateaux.

In mapping this succession of rocks, certain characteristic bands have been utilised, of which the chief are :

(1) the basal grits and conglomerates,

(2) the basal coal seam No. 1 with its associated pebbles,

(3) the grit above seam No. 13, and

(4) the grit above seam No. 25.

The grit above seam 13 is separated from the latter by a considerable thickness of black shales (33 to 153 ft.) and the latter from the coal seam itself by a few feet of shaly-sandy beds, which in places form a sandstone roof to the seam. These characters as well as the general succession, permit of the certain correlation of seam 13 of my area with Mr. Ward's Karagli seam.

The grit above seam 25 is usually characterised by felspar, which is specially abundant in the basal 2 ins. to 3 ins. resting direct on the worthless shaly coal seam.

In the above tabular statement seam 11 is correlated with Mr. Ward's Bermo seam, and seam 8 with Mr. Ward's Karo seams . The latter correlation is not quite certain. Mr. Ward's Karo seam is apparently composed of more than one seam, and may represent seams 8 and 9 of my area. This is one of the geological points I have not determined.

Seam 11 and 13 are of nearly indentical thickness throughout Sawang and Palihari-Gurudih, and this caused Mr. David to regard these two seams as the same seam repeated by faulting. They are really quite different in composition (seam 13- average ash = 17.18 per cent. : seam 11-average ash = 26.27 per cent.), and this confusion by Mr. David was one of the fundamental causes of his adverse report on the Gumiya section of the field.

In my prospecting operations the chief attention was directed to the middle group of thick seams, and seams 8, 9, 11, 12 and 13 were exhaustively sampled. Seams 8, 9, and 11 proved to be quite worthless, and will be given no further attention in this report.

Seam 12 contains one section of coal of workable quality, which will be referred to later, whilst seam 13 proved to be of the same quality as the coal being worked at the E.R.I. and B.N.R. Joint Colliery.

Of the overlying seams the majority are probably of little or no value, being usually too shaly, or, if good, too thin, and we need, in this report, refer further only to seams 15, 21 and 22, of which the two latter contain first-class fuel.

Brief consideration will now be given to seams 12, 15, 21 and 22, before discussing the all-important seam 13.

2. Seam 12.

Seam 12 has been identified only on the northern edge of the field. It was first discovered by me from a burnt outcrop and tested as to its thickness by D.D.H. No. IV (*see* p. 13). The cores and washings obtained were analysed separately and the analyses of the corresponding section of the seam deduced therefrom. The results, showing ash contents only, were as follows :

Samples.	Vertical Footage. Ft. Ft.	Ash contents (deduced) Per cent.
F. 132 and F. 132A	93—98	26·11
F. 133 and F. 133A	98—103	20·63
F. 134 and F. 134A	103—108	19·96
F. 135 and F. 135A	108—118	15·35
F. 136 and F. 136A	113—118	22·66
F. 137 and F. 137A	118—123	50 10
Not sampled	123—124′2″	..

The method of combining the analyses of the cores (F. 132 to F. 137) and the corresponding washings (F. 132 A to F. 137 A) has been specially divised as a part of this investigation and will be explained in the full report. It is sufficient to say here that, even when conducted with the utmost care it still gives unfavourable results. The best results hitherto obtained (on seam 13) gave the ash contents 2 per cent. higher than is a sample actually cut in a prospecting shaft about ¼ mile away, but the error in many cases is much higher (*e.g.*, 5 per cent). It is probable, therefore, that the 5 feet of coal showing 15·85 per cent. ash above, really runs below 15 per cent in ash, probably about 14 per cent. The 5 feet of coal, running 19·96 per cent. ash, is almost certainly as low as 17 per cent. in ash and quite possibly as low as 15 per cent.

An outcrop of this seam was eventually found in a *nala* in Gobindpur where, however, the coal is partially coked by an intrusion of mica-peridotite. The section was as follows :

Ft.	In.	Top.
1	9	Mica-peridotite sill.
2	0	*Jhama* (coke).
5	0	Coal-sample F. 19.
5	3	Coal-sample F. 120.
7	0	Mica-peridotite and *Jhama*.
3	0	Coal-sample F. 121.
0	6	Basal coal.
22	9	

The analyses were as follows :

No.	Footage.	Moisture.	Volatile matter.	Fixed Carbon.	Ash.
		Per cent.	Per cent.	Per cent.	Per cent.
F. 119	2′—7′	0·88	20·62	56·20	22·30
F. 120	7′—12′3″	1·20	20·25	63·24	15·31
F. 121	19′3″—22′3″	1·50	17·79	49·98	30·73

The composition of the portion (12 ft. 3 ins. - 19 ft. 3 ins.) represented by 7′ of mica-peridotite and *Jhama*, is of course unknown, but if one compares the foregoing section with that of the coal seam in D.D.H. IV of Sawang, it is impossible to resist the conclusion that the upper portion of this coked section was possibly also coal of good quality. If one allows for a proportional reduction of thickness, some 2 feet of this was probably of first-class quality.

We see then that seam 12, as judged from two localities, contains a section of 5 feet of coal near the centre of the seam assaying about 15 per cent. in ash contents, with a possibility of an extra 2 feet in Gobindpur and 5 feet in Sawang of coal of good quality. This seam as encountered in P.D.H. (percussion drill hole) No. 12 in Pipradih, was 20½ feet thick, so that it is evidently thinning in both directions (east and west) from D.D.H. IV.

Seam 12 is not exposed on the southern side of the syncline on account of the boundary fault, and is absent in the Godo *Nala* on the Joint Colliery. We cannot, therefore, assume that it underlies the southern portion of the field in Jarangdih.

As this seam lies about 125 feet below seam 13, the factor of high depth, which will militate so seriously against the possibility working of portions of seam 13, will apply to this seam with even greater force. Where seam 13, however, is worked, it should in some cases be practicable to carry the shafts down to the underlying seam 12.

3. Seam 15

After comparing a careful section by Mr. Whitworth of the strata passed through in diamond-drill boring No. 1 on the Great Indian Peninsula Colliery at Kargali, I consider it probable that Mr. Ward's 12′ seam in that area is the same as my seam 15. Mr. Whitworth is working this seam (it is 10′-9″ thick in the boring)and finds the coal to be of first class quality and superior to the coal in the Kargali seam.

The samples of seam 15 passed through in my area suggested a very inferior seam, so that I made no attempt to dig it out and sample it. In view of the above, however, seam 15 should be investigated when this field is blocked out. The following core samples were analysed : —

No. of borehole.	No. of sample.	Footage.	Ash.
			Per cent
II . . .	F. 72 (cores) . .	19 ft.—31 ft.	22·70
	F. 72A (washings) .		22·42
V . . .	F. 149 (cores) . .	299 ft.—305 ft.	34·56
	F. 149A (washings) .		34·49
VII . . .	F. 188 (cores) . .	741 ft. 4 ins.—747 ft.	27·33
	F. 188A (washings) .		27·86
	F. 189 (cores) . .	747 ft. —752 ft.	41·88
	F. 189A (washings) .		21·02

From the above analyses it is evident that this seam is of very variable composition and that it would require a very liberal allowance for errors due to the samples having been obtained from bore holes before any of the above analyses could be regarded as indicating a workable seam.

4. Seam 21

This and the next seam (22) were sampled in small prospecting inclines in a *nala* in Gobindpur opened up by the diamond driller to obtain fuel for his boilers. The section was as follows :

Ft.	In.	Top.
0	3	Stony coal.
1	0½	Bright ,,
0	2½	Stony ,,
0	3	Bright ,,
0	5	Stony ,,
0	9	Bright ,,
0	1	Stony ,,
1	7	Bright ,,
4	7	

Two samples were cut, one (F.210) representing 3′7½″ of good bright coal and the other (F. 211) 11½″ of stony coal. The results were as follows :

No.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	
	Per cent.	Per cent.	Per cent.	Per cent.	
F. 210	1·05	27·17	58·92	12·86	
F. 211	0·62	23·46	28·42	47·50	
S.	—	—	0·590		F. 210
P.	—	—	—		F. 210
Calorific value	—	—	7,380 calories		F. 210

If this seam were to be worked, it would of course require picking to remove the 11 inches or so of stony coal. This, however, would be easy, as the stony coal is easily separable from the bright coal.

The area underlain by this seam is practically the same as for seam 22 (q.v.) which lies only some 25 ft. higher in the section.

5. Seam 22

This, like seam 21, is a banded seam. The section is as follows :

Ft.	In.	Top.
0	1	Stony coal.
1	3	Bright ,,
0	1½	Shale.
0	7	Bright coal.
0	4½	Stony ,,
1	8	Bright ,,
0	2	Coaly shale.
1	8	Bright ,,
0	1	Coaly shal
6	0	

Two samples were cut, one (F.212) representing 5′2″ of good bright coal and the other (F.213) the 4½″ band of stony coal, the other inferior bands were not sampled. The results were as follows :

No.	Moisture.	Volatile matter.	Fixed carbon.	Ash.
	Per cent.	Per cent.	Per cent.	Per cent.
F. 212	1·16	27·7	59·38	11·76
F. 213	0·83	20·33	58·02	20·82

S.	..	..	0·560%	F. 212
P.	..	..	0·288%	
Calorific value	..	..	7,490 calories.	

As with seam 21, picking would be necessary but easy. Both these seams contain first-class coal of high calorific value, and must be regarded as a valuable asset in Gobindpur, where they have been tested.

What appear to be the same two seams were also encountered in the deep bore-holes VIII in Sawang and XV in Jarangdih with approximately the same thickness as in Gobindpur. If I am correct in my correlation, these two seams must, therefore, underlie a very considerable area in Sawang, Khudgara, Hazari, Gobindpur and Jarangdih. It is impossible to be certain from the diamond drill cores whether the quality remains as good, however, but this would be easily ascertainable when sinking deep shafts to cut the Kargali seam, as such shafts would first pass through seams 22 and 21. Furthermore, the outcrops could be unearthed in Jarangdih and Sawang and samples taken.

Whilst these two seams cannot by themselves be regarded as sufficiently extensive to justify a railway extension into this part of the field, they will probably be found to form a very useful adjunct to the Kargali seam which will be the main source of fuel in this field.

B. Seam 13—the Kargali Seam.

1. General.

This seam was designated the Kargali seam by Mr. Ward, and is now being worked in the East Indian Railway and Bengal Nagpur Railway Joint Colliery at Baidkaro and the Great Indian Peninsula Colliery at Kargali both on the N. E. side of the Gobindpur fault. The thickness in this area varies from a minimum of about 70 ft. on the Great Indian Peninsula Colliery to a maximum of 104 ft. on the Joint Colliery.

To my earlier report I appended a sketch map showing the distribution of this seam on the west side of the Gobindpur fault, *i.e.*, in the Gumiya section of the field. The Barkar rocks here form a syncline, of which a large portion of the southern limb has been faulted out, *e.g.*, in Jarangdih. The result is that on this side of the syncline seam 13 does not crop out at the surface—D.D.H. XV, sunk this season, cut this seam at 1,407 ft. from the surface, the seam showing the exceptional thickness of 121 ft. measured vertically. This is also practically the true thickness, as the dip of the seam is only 4 deg. as judged from the cores.

On the north side of the syncline the seam crops out at the surface, but has been faulted into sections as shown in the sketch map. These sections may still be designated by the letters used in the earlier report.

The sketch map attached to that report shows the Kargali seam as underlying a stretch of country bounded on the north by a fault in Palihari-Gurudih and by the outcrops of the seam itself in Sawangand Gobindpur; on the east and north-east by the Gobindpur fault and on the south by the Damodar river and the Kathhara fault; whilst on the west the seam doubtless extends beyond Gumiya, Hosir and Sarum under Lugu Hill, but probably with an ever decreasing thickness of coal and an ever increasing thickness of overburden. My stay west of Lugu Hill was a brief one, but the time at my disposal should have enabled me to identify the Kargali seam by means of its associated rocks, had it persisted so far without a radical change in character. As, however, I was unsuccessful in this report, I think it likely that the Kargali seam has continued to decrease in thickness towards the west, and that this change has been accompanied by a lateral change in the thickness or character of the overlying rocks, so that the Kargali seam is no longer recognisable west of Lugu, and is also, if present, probably of little or no value as an asset to West Bokaro.

In considering the economic features of East Bokaro I do not think we need pay any attention to Hosir and Sarum and to the ground west of the edge of my sketch map. This leaves some 15 or 16 sq. miles of ground as possibly underlain by the Kargali seam.

On my map I have shown the Kathhara fault inserted by previous workers. I have not, however, resurveyed this fault. Instead, I have inserted another very important fault starting in the south-west corner of Jarangdih, where it merges into the boundary fault, and running west-north-west through the north-east corner of Kathhara, across the southern part of the Borea, touching the southern edge of Bhurkundwatand, and then across Mahlibandh, where the fault appears to break up into a multitude of faults crossing the Bokaro river into the southern part of Hazari. This fault may be called the Borea fault. The downthrow is to the north to an amount unknown. Upon the amount of the throw depends, however, the existence of the Kargali seam under the ground on the south side of this fault. Upon this point I cannot at present express an authoritative opinion. I think a portion of the ground in question is probably underlain by seam 13 and have so shaded it on the sketch maps but the ground is so disturbed that the seam, if present is probably too broken up to be workable. Future investigation might, however, reveal areas of less disturbed ground with the seam relatively near the surface, and this portion of the field (Palani, Jhirki, Bandh, and Kathhara) cannot yet be put aside as worthless, but for our present purposes we must leave it out of account.

Excluding Jaridih as too disturbed, and the ground south of the Borea fault as also probably too disturbed, we are left with a strip of ground with an area of about 10 sq. miles—bounded on the north by the outcrops of seam 13 and the Gobindpur fault and on the south by the Bokaro river and the Borea fault—as requiring detailed consideration.

Before reviewing briefly the additions to our knowledge of the distribution of this seam resulting from the second season's field work, it will be convenient first to tabulate the results of all the diamond drill borings carried out during both seasons. Of these holes Nos. I to VII with a total footage of 2,474 ft. were drilled by Messrs. Shaw Wallace & Co., during the first season, and Nos. VIII to XVI with a total footage of 5,873 feet by Messrs. Kilburn and Company during the second season. The total footage for the two periods was therefore 8,347 feet. I changed the drilling contractors, because Messrs. Shaw Wallace and Company were not prepared to undertake drilling to the depths to which I proposed to explore during the second season, The work of both firms has proved reliable.

We will now discuss the season's prospecting in order from west to east.

No. of hole.	Village.	Seam drilled for.	Seams cut.	Depth of seam drilled for.	Vertical thickness of seam drilled.	Total depth of hole.
				Ft. In.	Ft. In.	Ft. In.
I	Sawang	13	17 to 13	480 0	49 0	541 0
II	Ditto	13	15 to 13, 11 (base of 13 and No. 12 faulted out).	186 0	23 0	313 0
III	Pipradih	13	13	77 0	41 0	126 0
IV	Sawang	12	12	93 0	30 0	131 0
V	Ditto	13	17 to 13	505 0	51 0	566 0
VI	Gobindpur	13	15 to 13	396 0	{ 50 0 *Jhama* 6 0 M.P.* }	524 0
VII	Ditto	13	14 and 13	203 0	{ 4 0 *Jhama* and M. P. 31 0 Coal. 16 0 Coal 24 6 *Jhama* with M.P.	265 0
VIII	Sawang	13	29 to 20, fault 17 to 13.	966 0	6 0 M.P. 3 0 *Jhama*. }	1,030 0
IX	Palihari-Gurudih	25	26 and 25	149 0	16 6	173 0
X	Ditto	25	Fault, 22, 21	..	..	204 4
XI	Gobindpur	13	25 to 13	1,158 0	{ 21 0 Coal 0 4 *Jhama* 0 4 M.P. 26 10 Coal }	1,215 6
XII	Palihari-Gurudih	Palm-tree fault.	Seams not identified.	..	..	374 6
XIII	Ditto	13	11	298 0 (Seam 11)	56 0 (Seam 11)	416 0
XIV	Ditto	25	25, 23	26 6	16 6	140 6
XV	Jarangdih	13	26 to 13	1,407 8	121 4	1,535 0
XVI	Hazari	13	Overlying seams not yet identified 15 to 13.	725 0	50 0	785 0

* M.P. = mica-peridotite.

2. Section. E.—Palihari-Gurudih and Gun iya.

Last season the most westerly outcrop of seam 13 identified was the section marked H, which was cut out to the west by a W.N.W. fault (the Palm-tree fault). This season I sank a series of bore holes in Palihari-Gurudih, which is almost entirely shruded in alluvium, in an attempt to discover the Kargali seam in this area.

D.D.H.IX was drilled on an outcrop of grit which I had deduced to be the grit above seam 25. The drilling proved the correctness of my deduction, and gave me a datum line. (We know now that if a deep boring were drilled at this spot, seam 13 would be cut at about 1,200 ft. from the surface—1,044 ft. below the top of seam 25 by calculation—if no faults cut the hole.)

D.D.H.X was drilled further west on another similar outcrop assumed to be the same grit. A fault was cut, and seam 25 was not found, so that the evidence here is inconclusive.

D.D.H.XII was drilled to determine the hade of the Palm-tree fault, and on the information obtained D.D.H.XIII was located with the expectation of cutting seam 13 at about 700 ft. from the surface. Instead of this, seam 11 (the Bermo) was cut at 295 ft. from the surface, proving either that the Palm-tree fault had ceased or that another fault had intervened.

This drove me back to D.D.H.XIV between IX and X which also proved seam 25.

The result of this campaign in the alluvial ground of Palihari-Gurudih is to prove that the outcrop portion of seam 13 is faulted out probably by an easterly prolongation of the northern boundary fault of Lugu Hill. It is, therefore, doubtful if Palihari-Gurudih contains any portion of seam 13 nearer the surface than about 1,000 ft, so that the line of borings IX, XIV and X may be regarded as marking a contour in seam 13 at about 1,200 ft. below the surface, but with practically all the coal to the rise faulted out.

The Kargali seam underlies, therefore, only the southern portion of Palihari-Gurudin but probably the whole of Gumiya, except for faulted ground. As practically all the coal lies at depths of 1,200 feet and upwards, I doubt if under present conditions it would pay to establish a colliery to work coal in Palihari-Gurudih and Gumiya (except on strip H referred to below).

Shafts could be sunk to cut the seam at 1,200 ft. from the surface, but as then practically all the coal would lie to the dip, a depth of 1,500 ft. might be considered preferable. The ground may prove rather faulted in the shallower Palihari-Gurudih portion where also the dips are variable and usually high (12 deg. to 30 deg.).

3. Outcrop H.

As will be seen by comparing this map with last year's the fault shown as cutting of this outcrop just east of D.D.H. III has proved on further examination, to be non-existent, and this section of the outcrop has been proved to continue as far as the north-western fault (j), giving this portion of the outcrop a length of about 1,200 yds. The throw of the Palm-tree fault decreases rapidly to the south-east, so that within block A the effects of this fault are not of the same unfortunate nature as in Palihari-Gurudih.

4. Outcrop J. K. (Sawang).

In my earlier report I recommended the demarcation of block A of the standard size, taking in portions of Sawang, Hazari and Khudgara villages. This recommendation was based on the evidence of D.D.H.V. and I, which each cut the seam at about 500 ft from the surface, passing through 49 and 51 ft. of coal respectively. But I advised at least one deeper hole to cut the seams at about 1,000 ft. as a precautionary measure in order "to ascertain, what seems probable, that the seem has not been affected by intrusions of mica-peridotite in depth". Unfortunately, this precaution proved only too necessary, for D.D.H.VIII, drilled this season, cut the seam at 966 ft. and showed the following section of the seam :—

Ft.	In.	Top.
15	0	Coal.
3	0	,, partly coked.
22	6	*Jhama* with mica-peridotite.
6	0	Mica-peridotite.
3	0	*Jhama.*
49	6	

This result is, of course, highly damaging to the prospects of this block. In order to obtain an idea of the extent of the coking, I then sank the deep hole XI at Gobindpur, and happily found the seam at this point practically uncoked (*see* p. 13). Accordingly, I brought in the drill to an intermediate point and selected a site for D.D.H.XVI near the eastern edge of block A in Hazari. The seam was reached at 785 ft. from the surface, some 300 ft. sooner than expected, due, no doubt to the presence of a fault, *but, happily, the seam showed no signs of mica-peridotite or coking. We see, then, that the serious coking of seam 13, detected in D.D.H.VIII does not extend as far as D.D.H.V, I, or XVI; it is, therefore, localised, but to what extent cannot be determined without further deep borings, especially in the south-west portion of the block.

Of the six boreholes sunk on this block, three, *viz.*, I, VIII, and XVI, have passed through faults, and the detailed maps show numerous faults, especially in the deeper portions of the field; there is consequently no doubt that the working of this block will not prove plain sailing.

5. Gobindpur (Strips B and C).

From the earlier report it will be seen that strip B is seriously coked near the surface, but that in D.D.H.VII only 2 ft. of *jhama* was found; whilst the only borehole (No. VI) on strip C showed the seam to be entirely coked.

D.D.H.XI was drilled on strip B this year, starting from the grit above seam 25. The Kargali seam was reached at 1,158 ft. from the surface the section of the seam being:

Ft.	In.	Top.
21	0	Coal.
0	4	*Jhama.*
0	4	Mica-peridotite
26	10	Coal.

A deep borehole on strip C would also be desirable to determine whether the coking becomes less or even ceases to the dip. But, even without this, we may affirm that a considerable area of the seam in south-west Gobindpur is probably workable.

6. Jarangdih and Borea.

A deep boring (XV) was drilled in Jarangdih to determine the presence of the Kargali seam. The site had to be selected with the greatest care. To the south lay the boundary fault between the Crystallines and the Barakars, hading to the north. Consequently, one could not drill too far south for fear of cutting the fault before the coal seam. Numerous outcrops of mica-peridotite near this boundary also made it desirable to drill as far north as possible without choosing a spot at which the seam would prove to lie at too great a depth.

As a result of the detailed surveys carried out, I was able to pick upon a particular band of grit in Jarangdih and correlate it with a certain degree of probability with the grit over seam 25 in Sawang on the north side of the syncline, although the two outcrops could not be traced to within some 2½ to 3 miles of each other. On the basis of this correlation, however, I selected a site at which I expected the Kargali seam to lie some 1,250 ft. below the surface if the strata showed the same thickness here as on the north side of the syncline. The boring proved my correlation to be correct, and seams 26 to 13 were cut successively in the bore hole.

Seam 13 was not, however, reached until a depth of 1,407 ft. from the surface, due chiefly to the thickening of the strata between seams 14 and 13, the black shales alone being 153 ft. thick. This thickening of the shales was accompanied by a thickening of the underlying coal seam to the unexpected figure of 121 ft. 4 inches, there being no signs of the intrusion of mica-peridotite. In Jarangdih, therefore, we have the thickest part of the Kargali seam as at present known. It will need some shallower borings to the south east of the D.D.H.XV. to determine how much coal lies to the rise before the boundary fault cuts out the seam. But there is no doubt that a great

* I have not yet been able to examine the cores from this hole.

quantity of coal lies to the dip of D.D.H.XV in Jarangdih and Borea, but at constantly increasing depths as one passes north-westwards. The strata in Jarangdih west of the nala known as the Nunia Chhapa Nala and as for as the Borea fault have a very regular dip to the north-west quadrant at angles constantly decreasing to the north-west. Thus the dip on the Jarangdih Borea boundary is 13 deg., and this decreases to zero at the centre of the syncline in the north-west corner of Borea. This ground seems also to be completely free from faults except for a trivial fault or two in the Nunia Chhapa Nala. The portions of Jarangdih east of this nala are much obscured by alluvium and may prove to be considerably faulted, and further boring would be required to determine the prospects of the eastern portion of Jarangdih.

C. Quality of Coal in Seam 13.

This has been carefully determined at four points : —

(1) in the Godo Nala on the Joint Colliery.

(2) in the shafts on the Joint Colliery.

(3) in the faulted remnant in the Dharmagia Nala in Jarangdih, on the east side of the Gobindpur fault, and

(4) *in prospecting pits 1 and 2 in Sawang.*

The results were as follows :

1. *Godo Nala.*

Mr. Ward in a series of pits on the section of the seam west of the Godo Nala fault obtained the following results : —

Section.			Moisture and volatile matters.	Fixed carbon	Ash.	
	Ft.	In.	Per cent.	Per cent.	Per cent.	
Coal	43	0	29·0	57·5	13·5	Average 14·94 per cent. ash.
Shaly coal	14	6	26·5	52·0	21·5	
Coal	23	0	29·0	57·5	13·5	
Total ..	80	6	..	..		

On these analyses the first two blocks were demarcated.

2. Joint Colliery.

In sinking these shafts, Mr. Brown took a sample every foot, the ash percentage; of these samples varying from 6·45 per cent. to 43·1 per cent. The seam evidently possesses a very banded structure with alternating bands of good and poor coal. I have grouped the analyses as follows :

Footage.	Ash contents.	Footage.	Ash contents.
Ft. Ft.	Per cent.	Ft. Ft.	Per cent.
0—7	19·45	50—55	15·74
7—12	12·11	55—60	14·52
12—17	16·49	60—65	16·43
17—24	14·27	65—68	16·72
24—29	23·07	68—73	14·90
29—34	16.30	73—82	20.99
34—40	17·80	82—87	14·54
40—46	15·82	87—89	20·12
46—50	28·76		
Average (0—89 feet)	..	..	17·45

From these figures it will be seen that the simple subdivision of the seam detected by Mr. Ward in the Godo Nala does not persist in the shaft area, but that bands of stony coal are found at intervals throughout the seam and are not concentrated into a middle section. Thus, of the 89 separate samples summarised above the following show 20 per cent. of ash and over :

3,4,6,11,14,25,29,34,38,39,44,47,48,50,54,60,74,78,79,80,82,88.

These figures show that bands of coal averaging 20 per cent. of ash and over are scattered throughout the full thickness of the seam.

In actual practice the entire thickness of this seam is being worked in the quarry area of this colliery, the stony coal being picked out as far as possible. A sample taken by me from 24 railway wagons at the Joint Colliery showed :—

Sample F. 153.

	Per cent.
Moisture	1·6
Volatile matter	23·57
Fixed carbon	58·96
Ash	16·31
	100·00
Sulphur	0·465
Calorific value	7,140 calories.

3. Dharmagia Nala, Jarangdih.

This faulted fragment of the Kargail seam is exposed in a *nala* of the above name, and was sampled by me from a trench cut right across the seam by some previous prospector and deepened by me. The horizontal distance across the seam was 171 ft., which with an average dip of 33 deg., gives a thickness of 93 ft.

The seam proved to be banded, as at the Joint Colliery, and consequently I sorted each of the majority of the samples into two portions, one containing the good coal and the other the shaly and stony coal. Each sample of bad coal has the same number as the corresponding sample of good coal, but with the letter "a" suffixed. The results of analysis as regards ash contents only are shown below, the footages given being the horizontal measurements starting from the south-east or hanging-wall side :

Footage.	Sample No.	Ash contents.	Sample No.	Ash contents.
Feet.		Per cent.		Per cent.
0—21	F. 1	8·75	F. 1a.	18·84
21—32	F. 2	9·68	F. 2a	17·31
32—47	F. 3	14·16	F. 3a	23·53
47—65	F. 4	9·57	F. 4a	22·12
65—75	F. 5	15·29	F. 5a.	31·53
75—81	F. 6	15·38	Not sorted.	..
81—87	F. 7	19·70	Not sorted.	..
87—100	F. 8	13·57	F. 8a	17·60
100—121	F. 9	14·83	F. 9a.	27·19
121—141	F. 10	11·90	F. 10a.	18·34
141—155	F. 11	15·80	Not sorted.	..
155—164	F. 12	19·91	Not sorted.	..
164—171	F. 13	21·10	Not sorted.	..

The value of this seam obviously depends upon the proportions of good and bad coal. Five samples for various reasons were not sorted. All the samples were weighed. Excluding samples F. 7, F. 12 and F. 13, the aggregate weight of the samples of good coal was 29,093 grammes and of the samples of poor coal was 16,899 grammes, corresponding to a rejection of 36 per cent. of the seam in sorting, but leaving 64 per cent. of coal with only about 12 per cent of ash. This means, of course, that my sorting was unnecessarily drastic : it was certainly much more than would be effected in practice. The weighted mean of the whole seam is 16·54 per cent. ash, *i.e.*, without any sorting the Dharmagia Nala seam is as good as that raised from the Joint Colliery, and it could be despatched without any but the most obvious rejections. A rejection of some 15 per cent. of shaly coal would probably bring the ash contents down to about 15 per cent., so that the whole export would then rank as first-class coal.

The weighted mean given above was calculated from the separate samples on the basis of thickness represented, but a sample (F.14) was also compounded of half of the coal of each of the above samples. This gave the following results :—

	Jamalpur.	G. S. I.
	Per cent.	Per cent.
Moisture	0·97	1·25
Volatile matter	24·00	24·45
Fixed carbon	61·04	60·08
Ash	13·99	14·22
	100·00	100·00
Sulphur		0·64
Calorific value		6,918 calories.

The calorific value was determined with the bomb calorimeter, and is, therefore, not subject to reduction.

If we average up the two values of the ash contents (16·54 per cent. calculated and 14·11 per cent. mean of the two actual determinations), we obtain a value of 15·33 per cent. as the average ash contents of the Kargali seam in this area. This value, combined with Mr. Ward's value for the Godo Nala (14·94 per cent. ash) and compared with the average figure for the shaft area of the Joint Colliery (17·45 per cent.), suggests that the seam may be improving in quality as one passes west from Baidkaro to Jarangdih.

We have no means of ascertaining the quality of the coal on the downthrow side of the Gobindpur fault in Jarangdih, as not only are diamond-drill samples unreliable, but in the deep hole XV very few samples were obtained owing to the breaking up of the seam by the vibration of the drilling rods and the pressure of water forced down the hole. The outcrop in the Dharmagia Nala is, however, only about ½ a mile from the bore hole, so that we may assume that the coal pierced in the Jarangdih hole approximates to this in composition.

4. Sawang.

At a point to the rise of D.D.H. No. 1 a prospecting shaft was sunk through seam 13 to enable me to cut samples. As the top portion of the seam proved to be decomposed, a second pit was sunk to the dip of the first in order to reach the seam at a greater depth, and the top portion of the seam was sampled from the second pit.

The seam was sampled by a vertical cut down the side of the pit, all coal good and bad being included in the sample. The results were as follows :—

	No. of sample.	Vertical thickness.	Ash contents.	
		Ft. In.	Per cent.	
	F. 39	5 0	19·22	
	F. 40	5 0	17·57	
Pit 2	F. 41	2 6	12·72	
	F. 42	1 9	19·42	
	F. 43	2 3	19 25	
	F. 30	3 0	15·10	
	F. 31	5 0	17·60	
	F. 32	5 0	20·89	Weighted mean 17·79 per cent. ash.
	F. 33	5 0	16·90	
Pit. 1	F. 34	5 0	14·32	
	F. 35	5 0	19·90	
	F. 36	4 0	17·22	
	F. 37	1 4	23·44	

The results should be compared with those for the shafts on the Joint Colliery the similarity being very striking.

The coal extracted in sinking these pits was stacked separately for every 5 feet of depth. A brick and cement sampling platform was prepared, and the foreman-in-charge of my work, who had previously been a loading foreman, was told off to treat this platform as a railway wagon and load on to it only such coal as he would pass as steam coal, and to sort the remainder in to bad coal and slack. This work was, of course, done by coolies, so that the experiment must be regarded as a practical test. I then took for each 5 foot thickness of the seam three samples, representing steam coal, waste, and slack. The weighted means of the three samples gave the following results :—

	Ash contents.	Volume.
	Per cent.	c. ft.
Steam coal	15·74	1,233
Slack	18·05	1,365
Waste	31·12	212

The volume of the various stacks were also measured and the totals for each class of coal are shown above. The method of winning the coal was, of course, responsible for the high proportion of slack. From the ratio of steam coal to waste we can deduce that in actual parctice some 15 per cent. of coal would be rejected.

Whilst cutting the pit samples, I made notes, as far as was possible in the gloom and the water, on the banding of the coal seam. Perhaps these notes may be collected here so as to give an idea as to the banding of the seam :

Section Ft.	In.		Ash contents (Per cent)
5	0	fairly good with stone, coal and a little shaly coal . .	19·22
0	6	coal	
0	1	shaly coal	
1	1	coal	
0	1	shaly coal	
0	10	coal	
0	1½	shaly coal	
1	0	coal	
0	2	shaly coal	
0	1½	coal	
4	0	. . . .	17·57
2	6	no poor bands	12·72
0	2	coal	
0	3	shaly coal	
0	11	coal	
0	3	shaly coal	
0	2	coal	
1	0	. . . .	19·42
2	3	apparently all good	19·25
3	0	coal	15·10
0	3	coal	
0	2	shaly coal	
0	11	coal	
0	3	shaly coal	
0	11	coal	
0	2	shaly coal	
0	8	—	
0	2	shaly coal	
1	6	coal	
5	0	. . . .	17·6

Section. Ft.	In.		Ash contents. Per cent.
0	7	coal	
0	3	shaly coal	
0	5	coal	
0	1	shaly coal	
0	6	coal	
0	4	shaly coal	
0	8	coal	
0	3	shaly coal	
0	6	coal	
0	2	shaly coal	
1	3	coal	
5	0	. . . .	20·89
2	0	coal	
0	3	shaly coal	
0	5	coal	
0	3	shaly coal	
2	1	coal	
5	0	. . . .	16·50
5	0	. . . .	14·32
0	1	coal	
0	2	shaly coal	
0	7	coal	
0	3	shaly coal	
0	5	coal	
0	1	shaly coal	
2	8	coal	
0	4	shaly coal	
0	5	coal	
5	0	. . . .	19·90
0	1	shaly coal	
3	11	alternating good and shaly coal	
4	0	. . . .	17·22
1	4	banded bright and silky coal	23·44

From the foregoing analyses we may tabulate the following average value for the ash contents of the Kargali seam :—

	Thickness of seam.		Ash contents.
	Ft.	In.	Per cent.
Joint Colliery-Shafts	89	0	17·45
,, Train load	..		16·31
Godo Nala	80	6	14·94
Dharmagia N.-Jarangdih	93	0	15·33
Sawang-Pits	49	10	17·79
,, Steam coal (picked)	..		15·74

The designation to be applied to coal of this type depends upon the definition adopted as to the limits between second and first-class coal. F.C. Hughes takes 15 per cent. ash as the limiting value, with a calorific value of not less than 6,500 calories. The coal of the Kargali seam on the basis of the ash percentage alone would, therefore, be termed very good second-class coal. But the calorific value averages about 7,000 calories, so that in this respect the Kargali coal is much better than much first-class Raniganj coal. It might prove misleading, therefore, to call this coal second-class and we must recall that, according to the experience of the Railway Companies using the coal, it is a very useful fuel for all goods traffic.

The Sawang coal will prove to be of the same quality as that of the Joint Colliery and that of Jarangdih possibly a little better. In fact, the Jarangdih coal may prove, after picking out shaly bands, to be first-class coal as regards both ash percentage and calorific value.

D. Quantity of Coal in Seam 13.

We may first calculate roughly the total amount of coal underlying the villages of Palihari-Gurudih, Sawang, Gumia, Khudgara, Hazari, Gobindpur, Mahlibandh, Bhurkundwatand, Borea and Jarangdih, excluding the area lying south of the Borea fault and also Jaridih village as explained on page 12. This gives us an area of some 10 sq. miles over which the coal may prove workable from the structural point of view. The thickness of the seam ranges from 41 to 50 ft. on the north edge of the syncline and from 93 to 121 ft. in Jarangdih towards the south edge. The mean of these figures gives a thickness of 76 ft; but we have no knowledge of the manner in which the seam changes in thickness on passing from north-west to south-east, *e.g.*, whether the seam thickens gradually, or whether it thickens at first very slowly and then swells rapidly on approaching Jarangdih. In order to be on the safe side, we will assume the latter somewhat less probable alternative, and allow for an average thickness of only 65 feet.

With this thickness each square mile of coal-bearing ground would contain roughly $\frac{1760 \times 1760 \times 3 \times 3 \times 65 \times 62{\cdot}5 \times 1{\cdot}45}{2240.} = 73$ million tons.

The whole 10 sq. miles would then contain 730 million tons. But on account of the frequent faulting and of coking, which is serious in at least two places, we must make a liberal deduction from the above. Last year I assumed for the Sawang block a loss of 15,000,000 tons in 40,000,000 or 37·5 per cent. on account of faults and losses in picking. To allow for the coking detected in Sawang, we should now apply a further deduction of at least 12½ per cent. making 50 per cent. in all, and I think that we should assume for the whole 10 sq. miles a total deduction of at least 50 per cent. to allow for faults, coking, and picking. This leaves 365,000,000 tons of coal, which may be regarded as good fuel. Of course a considerable proportion of this coal lies at great depths (below 1,500 feet from the surface), and is, therefore, not easily accessible.

E. Demarcation of Blocks.

The portion of the field about which we now seem to have sufficient information to render possible the demarcation of blocks, is the 10 sq. miles referred to above. For the present I advocate dispensing with the southern portion of Gumiya, Khudgara and Hazari, on account of excessive depth of the coal and of faulting. The portion of the field to be blocked out is, in fact, the area bounded on the north by the outcrops of the Kargali seam, on the east by the Gobindpur fault and the Koonar river, and on the south by the Damodar river and the Borea fault and the south-west boundary of block A.

The standard shape and size of the blocks cannot, however, be advantageously retained in view both of the geological structure of the ground and of the existence of the Bokaro and Koonar rivers, which in the rains would prove formidable obstacles to passage from one part of a colliery to another, should any of the blocks be arranged so as to lie on both banks of one of these rivers. This, however, can be easily avoided, except in one case, and I would suggest that the area in question be demarcated into 5 blocks as follows. (*See* sketch-map attached to this report.)

1. Block I.

This is the most western block and includes portions of Palihari-Gurudih, Sawang, Gumiya and Khudgara. All the coal in this block will be deep coal, except for that in strip H, which could be worked from inclines as far as the Palm-tree fault. The remainder of the block would require to be worked through deep shafts (1,000 to 15,000 feet). The dips on strip H will probably prove to be about 15°, whilst on the remainder of the block the dips usually lie between about 18° and 30°.

2. Block II.

The boundaries of this are the same as those of block A of the previous report except that the N.E. corner has not been carried across the Koonar river, and the northern boundary has been placed slightly further to the north so as to include the outcrop of seam 12. The block comprises portions of Sawang, Hazari and Khudgara. As will be seen from the map there are several important faults traversing this block. This faulting and the existence of coking will necessitate great care in the selection of sites for shafts. There is no doubt that the shallow portions of the coal could be worked successfully through two shafts 500 ft. deep. The question for consideration is whether it will pay to sink deeper shafts. If the latter be decided on, further boring will be required to demarcate the extent of the coking before the shaft sites can be selected. In D.D.H.No. V the dip of the rocks by the time the seam was reached was still 15°, but in D.D.H.No. VIII the dip decreased from 16° at the surface to 5° by the time the seam was reached..

3. Block III.

The whole of the coal-bearing area in Gobindpur should be included in one block. Considerable portions of strip C will probably prove to be coked and a considerable area will be unworkable near the Gobindpur fault. The dip in D.D.H.No. XI decreased from 12° at the surface to 6½° between 660 to 900 ft. from the surface, increasing to 11° again by the time the seam was reached.

4. Block IV.

This is of irregular shape and bounded on the north and N.E side by the Koonar River, and on the south side by the Borea fault. It includes portions of the *mauzas* of Hazari, Mahlibandh, and Borea, and the whole of Bhurkundwatand. It is longer than the regulation measurement, but less wide, and is crossed by the Bokaro River, which would divide the block into two in the rains. Under all the ground S.E. of the Bokaro River the coal lies at a great depth, the centre of the syncline being in Bhurkundwatand and Borea (*See* p. 7) ; on the other hand, however, this portion of the block is very free from disturbances, with very low dips. North of the Bokaro the ground is very much more faulted, but in the north corner of the block the coal lies fairly near the surface (roughly about 350 ft. at the most northerly point). I doubt, however, if any one would at present regard this block as worth working.

5. Block V.

This is a strip about 2 miles long and from 1⅞ to 1½ miles wide, lying between the Koonar River and the Borea fault and comprising portions of Jarangdih and Borea. The ground on the north side of the Gobindpur fault is not underlain by seam 13, except for the small areas (S) represented by the outcrop in the Dharmagia Nala. The east end of Jarangdih is obscured by alluvium, but is evidently faulted and needs further investigation ; but the structure of the remainder of Jarangdih and of Borea is very simple and the rocks show a steady dip to the N.W. quadrant, decreasing from about 18° to 20° in the southern corner to 8° to 10° at the west end of the block. D.D.H.No.XV has proved the seam to be 121 feet thick at this point, and the outcrop in the Dharmagia Nala indicates an average ash contents of 15.33 per cent. As already indicated the southern limb of the syncline is faulted out, so that the Kargali seam does not crop out ; this will necessitate deep shafts (probably to about 1,500 ft.) with a large proportion of the coal lying to the dip, which by the way decreases from about 17° at the surface to 4° by the time the coal is reached in D.D.H.No. XV.

In spite, however, of the depth at which the coal lies, this block must be regarded as one of great value, both on account of the great thickness of the seam and of the steady dips (except in E. Jarangdih) and of the possibility that the coal in this area is of slightly better quality than elsewhere. If we assign an average thickness of 90 ft. to the seam over this block, it will contain about 170,000,000 tons of coal, of which if we deduct 50 per cent. to allow for faults, picking, and coking (which has not been proved to exist in this block 85,000,000 tons may be regarded as good fuel.

6. Relative Values of the Blocks.

Since the Railways and Bokaro and Ramgur Limited have to select their blocks in turn according to the agreement drawn up, I presume I am expected to express an opinion as to the relative values of the five blocks. This is, of course, exceedingly difficult, as it is impossible to predict the extent of coking, if any, due to intrusions of mica-peridotite, that will be found in each block. Judging, however, from the data at present available, I should place the order of value of these blocks as V, II, III, I, IV, No. V being placed first, in spite of depth of the coal—

(1) because it contains by far the largest quantity of coal,
(2) because this coal may be of somewhat better quality than elsewhere,
(3) because no coking has been proved to exist, although it must be remembered that only one boring has been attempted.

The Bokaro and Ramgur Limited has the next choice, I believe, and will probably not be disposed to work coal at 1,500 ft. The company would then be well advised to select block II rather than block V. and in this case the Railways would presumably select blocks V and III as their next two choices, leaving blocks I and IV to Bokaro and Ramgur Limited. If, however, it is the intention of Bokaro and Ramgur Limited to sell their next choice to a railway company—I have heard the Bombay Baroda and Central India Railway mentioned in this connection—then I think block V should command a higher price than block II.

After the demarcation and allotment of blocks it will in most cases be necessary for the owners of the respective blocks to incur further moderate expenditure on diamond drilling before the sites for shafts can be selected to the best advantage.

IV. Conclusion.

The foregoing pages summarise the facts elicited during this investigation that have a direct bearing on the economic future of both the West and East Bokaro Coalfields.

With reference to West Bokaro the conclusion that must be drawn is that the particular seams investigated in section 3 of that field do not contain workable thicknesses of either first-class or of good second-class coal. But although the prospects of West Bokaro seem unfavourable, only a detailed survey of the remaining portions of West Bokaro can finally determine this point.

In East Bokaro one seam is of outstanding value, namely seam 13, or the Kargali seam already being worked at the East Indian Railway and Bengal Nagpur Railway Joint Colliery, and at the Great Indian Peninsula Railway Colliery, to the east of the Gobindpur fault. To the west of this fault (the Gumiya section of the field) the

Kargali seam varies in thickness from 41 to 121 ft., and underlies at least 10 squar miles of ground ; and after making a deduction of 50% to allow for faults, picking and natural coking due to mica-peridotite intrusions, it is estimated that this area contains 365,000,000 tons of coal averaging about 16% in ash contents and 7,000 calories in calorific value, which is also the quality of the coal being railed from the Joint Colliery.

Unfortunately, owing to faulting and to relatively high dips at the margin of the syncline, a large proportion of the Kargali coal lies at considerable or great depths (1,000 to 2000 feet) from the surface, where, however, the dips are usually low (0° to 6°).

The question whether any considerable portion of this field could profitably be opened up in the near future (say the next 10 years) depends primarily upon two factors, namely the capital cost of equipping the necessary deep shafts, and the average price that coal of this quality would command from the time the producing stage was reached. As I can claim no first-hand knowledge of the former factor, the investigation must at this stage be handed on to the mining engineer.

The second factor is a matter for conjecture, but it will probably be agreed that the probable average price per coal of this quality is not likely to be less than Rs. 3-8-0 per ton during the next 10 years. Indeed, in view of the continued and preferential depletion of the true first-class coals of India, it is not unlikely that the market price of such fuel as the Kargali coal will eventually rise to a higher figure, probably to not less than Rs. 4-0-0 per ton, and this figure should also be taken into consideration.

But whatever views be taken as to the prospects of opening up the Gumiya section of East Bokaro in the immediate future, there is no doubt that we have proved the existence of a large reserve of coal, some of which will inevitably be mined in the not-too-distant future.

I have, therefore, suggested the division of the best portion of this area into five blocks (I to V), the boundaries of which are shown on the attached sketch-map.

L. L. FERMOR.

Dated, the 25th January 1918.

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FIG. 1—TALCHIR BOULDER BED AT CHAPRI

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FIG. 2—A CLOSER VIEW OF THE ABOVE

Photos: A. B. Dutt. *G. S. I., Calcutta.*

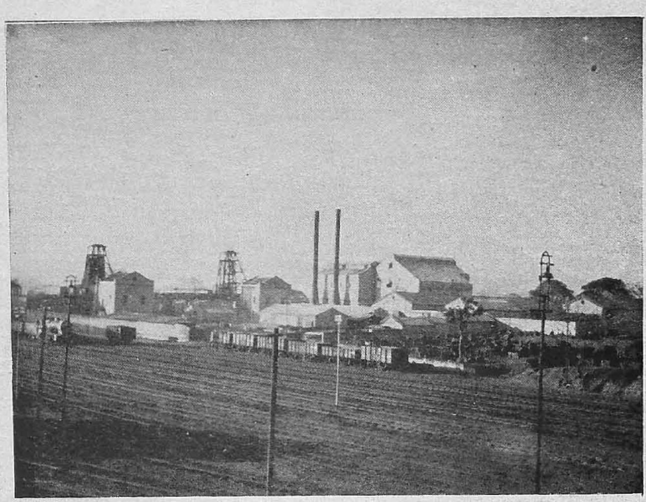

FIG. 1—KARGALI POWER HOUSE, COLLIERY DERRICKS AND SCREENING PLANT.

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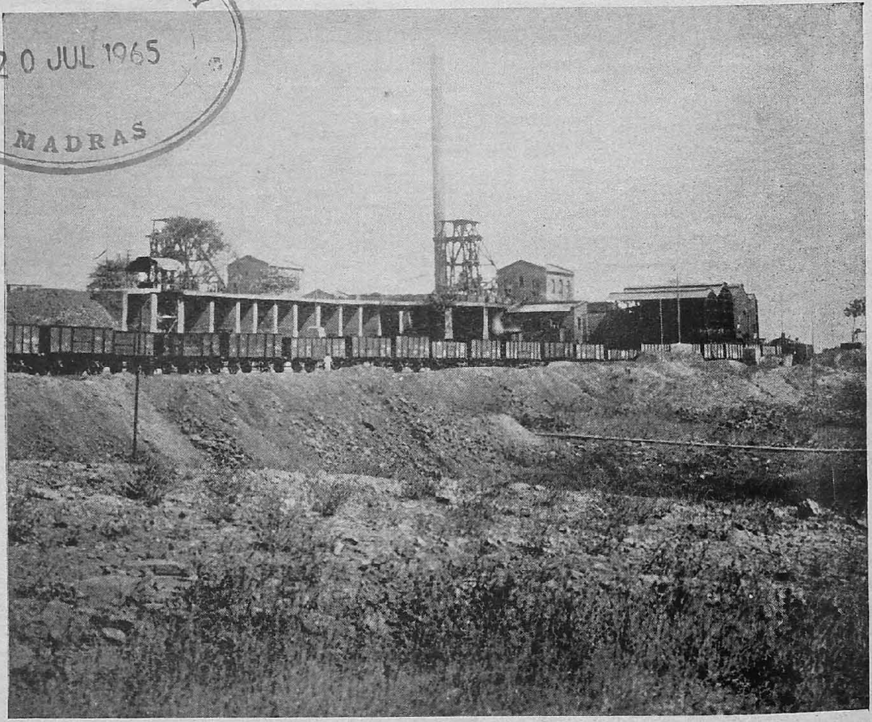

FIG. 2—SCREENING PLANT, BOKARO COLLIERY.

Photos : A. B. Dutt. *G. S. I., Calcutta.*

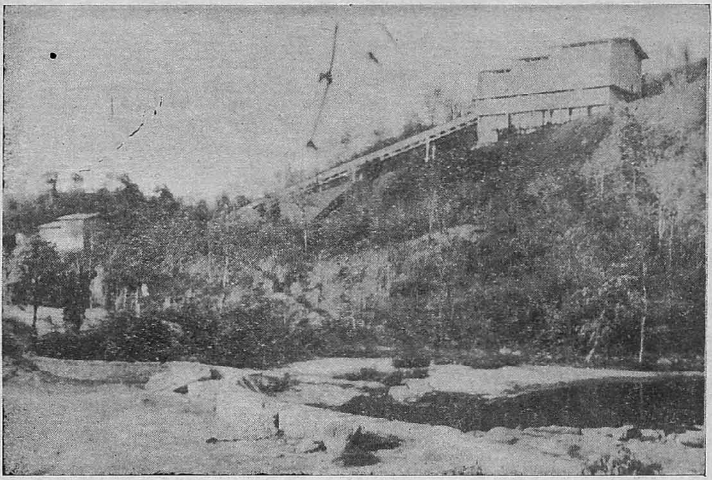

FIG. 1—COAL WASHERY IN WEST BOKARO COLLIERY.

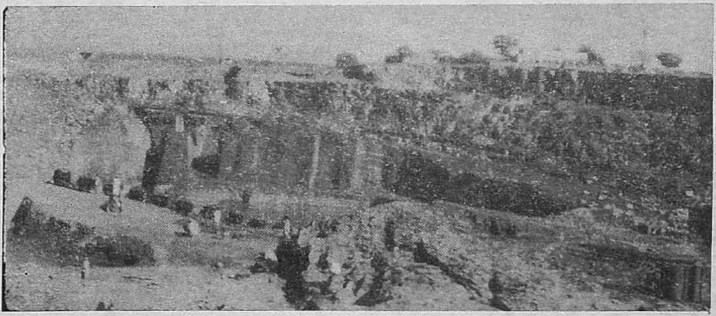

FIG. 2—A GENERAL VIEW OF THE BOKARO COLLIERY, QUARRY NO. 6

FIG. 3—"SCISSOR FAULT" IN THE BOKARO COLLIERY, QUARRY NO. 6.

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Photos: A. B. Dutt. G. S. I., Calcutta.

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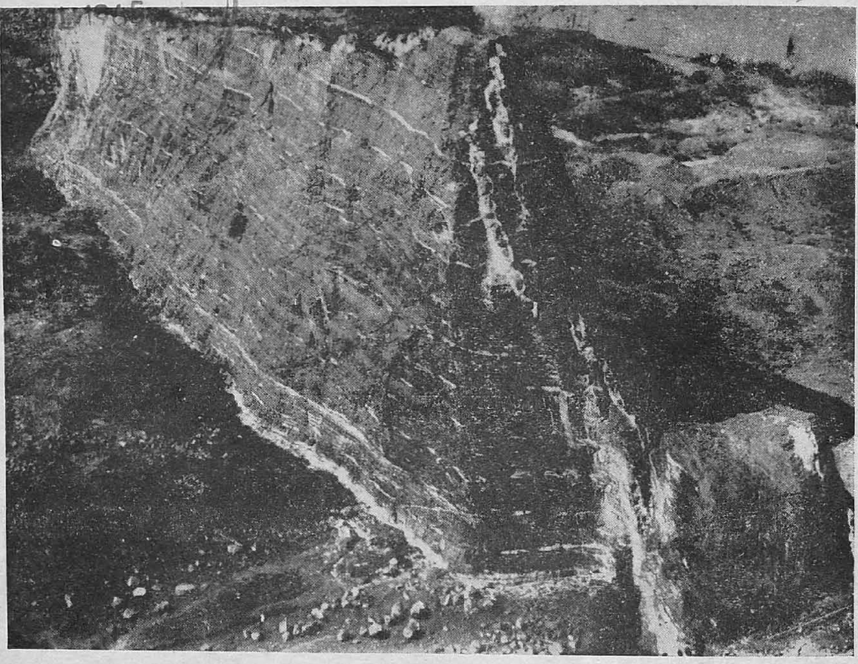

FIG. 1—MICA-PERIDOTITE INTRUSION INTO KARGALI SEAM, BOKARO COLLIERY, QUARRY NO. 5.

FIG. 2—KARGALI SEAM OPEN-CAST WORKING, KARGALI COLLIERY, QUARRY NO. 1. BROAD GAUGE WAGONS ARE SEEN.

Photos : A. B. Dutt.

G. S. I., Calcutta.

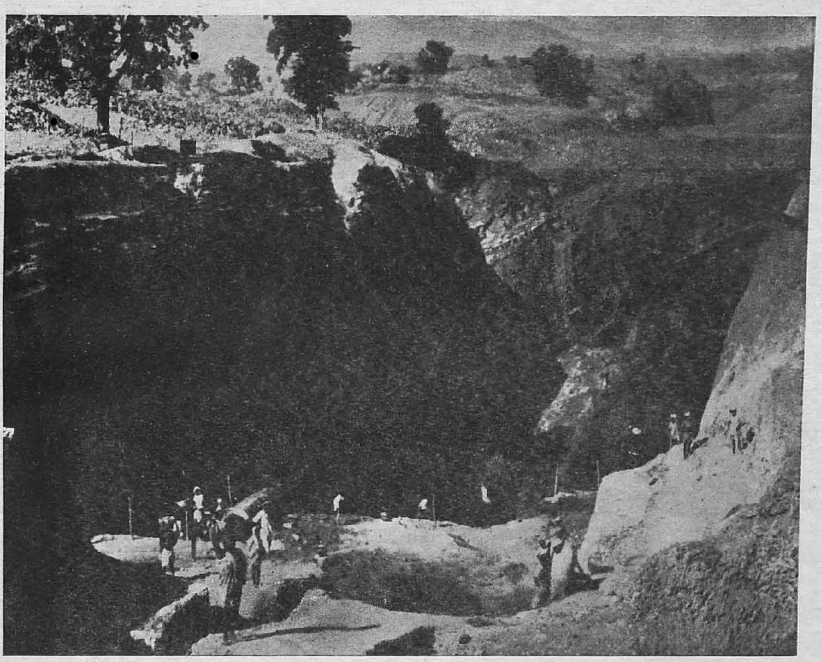

FIG. 1—COAL QUARRY AT SAWANG COLLIERY. BURNT ROCKS SEEN IN THE FOREGROUND.

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FIG. 2—FIRECLAY (lower band) UNDERLYING TOP KARO SEAM, NORTH-EAST OF EMLO.

Photos : A. B. Dutt. *G. S. I., Calcutta.*

FIG. 1—PRIMITIVE HAULAGE AT GOBINDPUR TRIAL SHAFT.

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FIG. 2—A GENERAL VIEW OF THE PIPRADIH COLLIERY.

Photos : A. B. Dutt. G. S. I., Calcutta.

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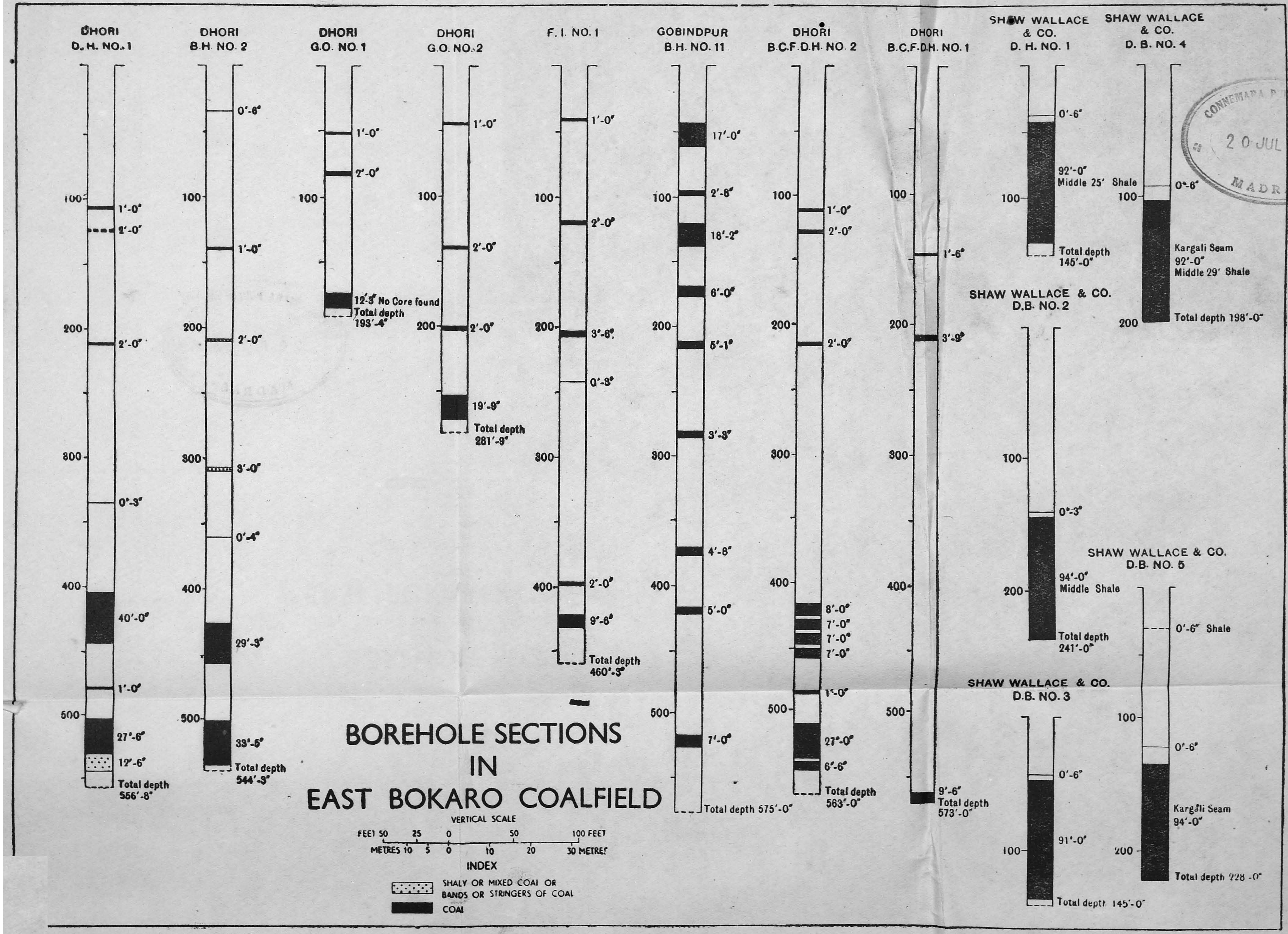

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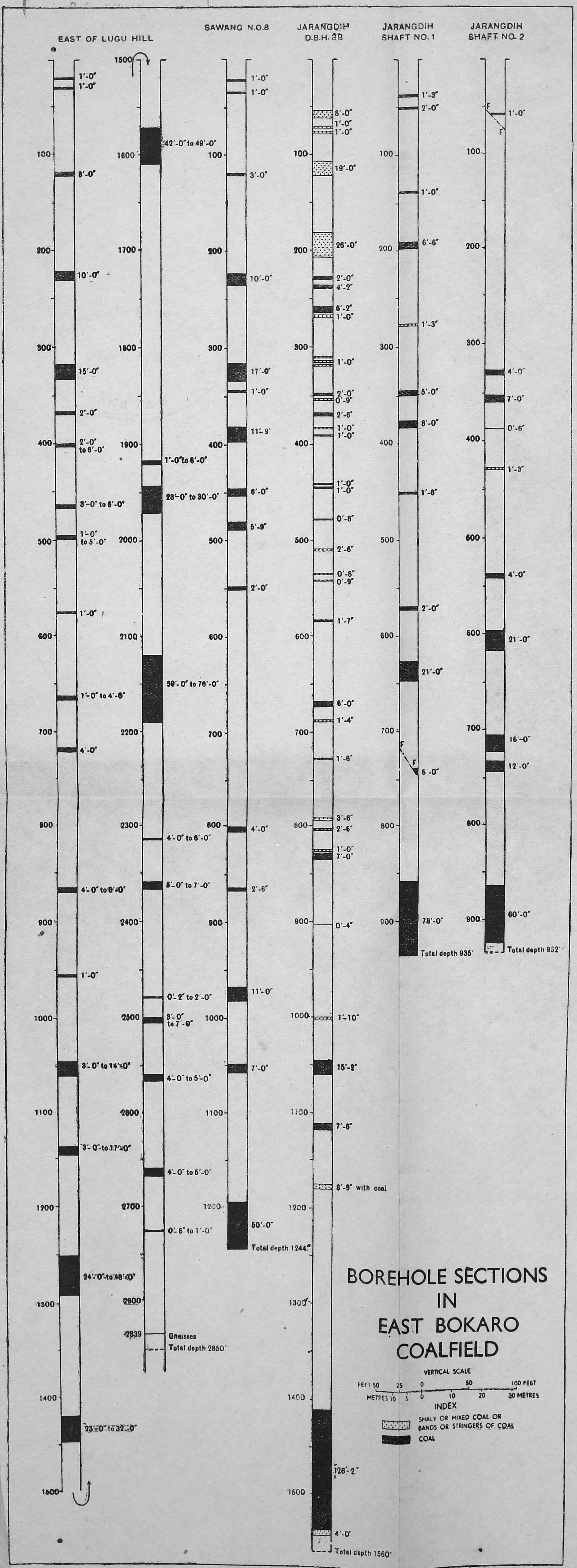

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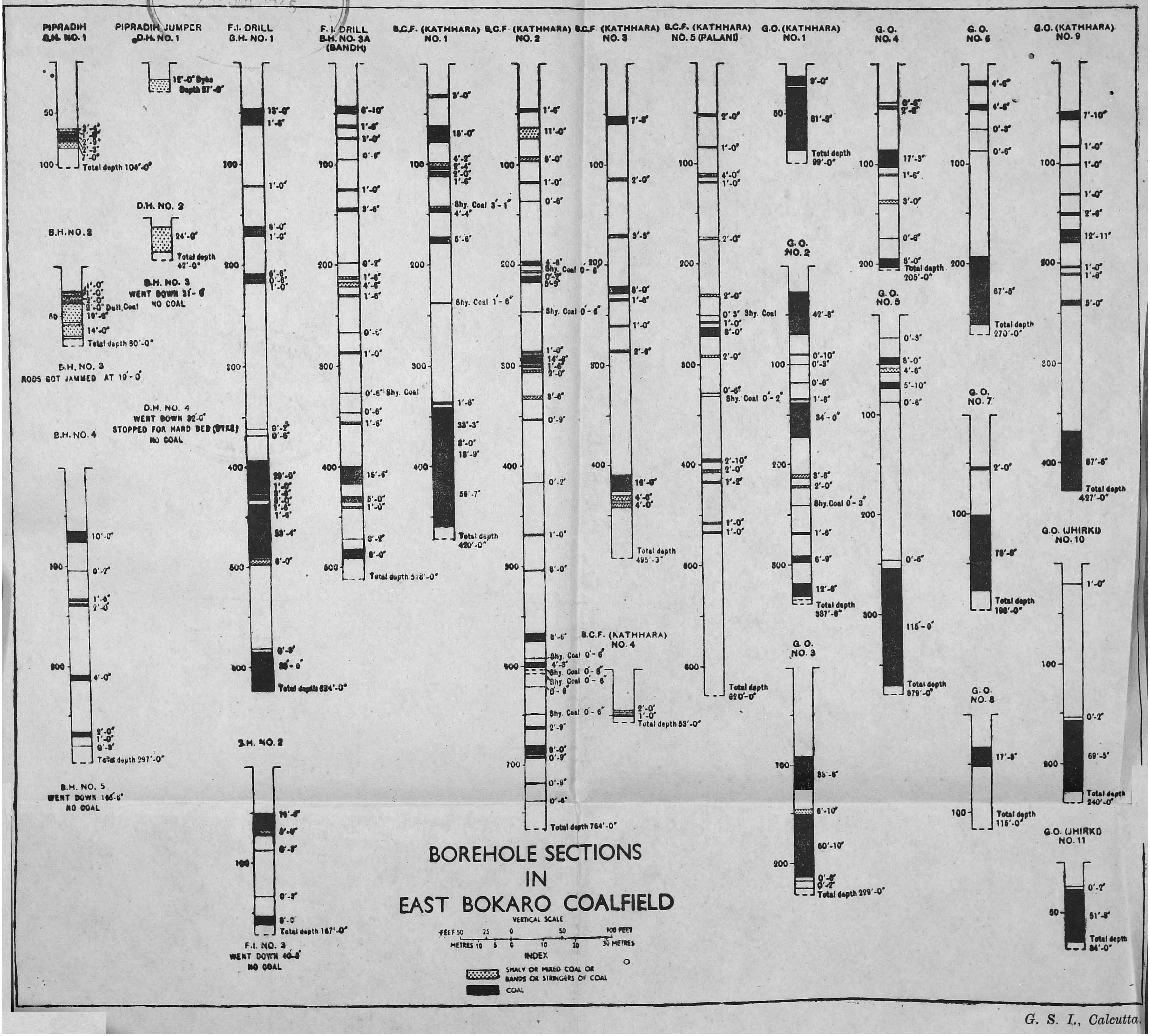

BOREHOLE SECTIONS IN EAST BOKARO COALFIELD

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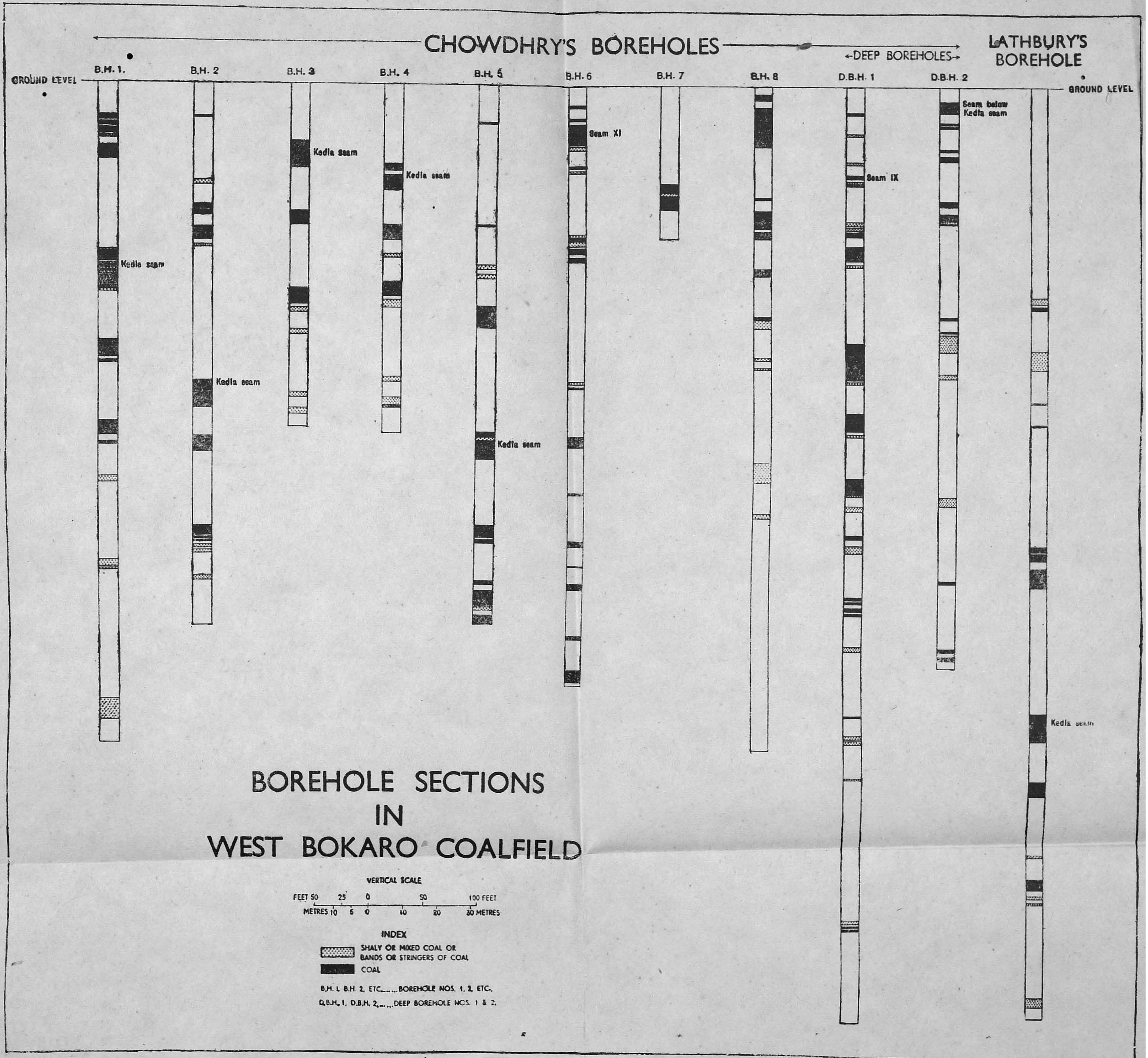

BOREHOLE SECTIONS IN WEST BOKARO COALFIELD

G. S. I., Calcutta.